COMMONWEALTH OF PENNSYLVANIA

GIANT POWER

THE REPORT

OF THE

GIANT POWER SURVEY BOARD

TO THE

GENERAL ASSEMBLY

WITH A MESSAGE OF TRANSMITTAL FROM

GIFFORD PINCHOT

GOVERNOR

In this report are discussed:

Railroad Electrification
Mine Mouth Power Plants
Gasoline from Coal
Farm Electric Service
National Defence
Power for Industry
City Gas Supply
Coal Pretreatment
Public Utility Regulation
Interstate Treaties
220,000 Volt Transmission
Water Power Development
Condensing Practice
Cost of Electric Current
Anthracite Culm
Landscape Beauty
Water Storage
Electricity in the Home

and other things of General Interest

Issued at the Capitol at Harrisburg, February 1925

REPORT

OF THE

Giant Power Survey Board

TO THE

GENERAL ASSEMBLY
OF THE
COMMONWEALTH OF PENNSYLVANIA

In Charge of the Survey
Morris Llewellyn Cooke
DIRECTOR
Judson C. Dickerman
ASSISTANT DIRECTOR

Electrical development has brought the Commonwealth to the threshold of momentous changes in industry and transportation and in the life of the people. 220,000 volt transmission unleashes all the potentialities of Pennsylvania as a power producing and power consuming state. To act wisely in this situation facts must be our guide.

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Governor Pinchot's Message of Transmittal

LADIES AND GENTLEMEN:

I have the honor to place in your hands the report of the Giant Power Board, a document certain to hold a high place in the history of the development and regulation of natural resources and their use in America. In doing so, I desire to lay before you some of the facts to which this report so vigorously calls attention.

Mechanical energy is the heart of modern civilization. It was the lack of mechanical energy—power—that kept men back so long in their struggle for control over the elements. It was the lack of it in large amounts which so long delayed the coming of the degree of safety and comfort which is now characteristic of human life in America. We owe the present American standard of living mainly to our use of greater quantities of power per inhabitant than any other people on earth.

From the very earliest times until about one hundred years ago the work of the world was done either by human muscle, by animal muscle, by the pressure of the wind, or by the weight of falling water. When the earliest Pharaohs ruled in Egypt, when Homer sang of the siege of Troy, when the first Christmas dawned to bless the earth, when Columbus discovered a new continent, when William Penn taught brotherhood in a new world, when Franklin laid the foundation for modern electrical development, when the Declaration of Independence was signed, men were still using the same four sources of mechanical power, and had never gone beyond them.

This limitation of available power circumscribed human activity and held back human progress to a degree we of today find it difficult to understand. If the ancients of the old world and the fathers of the new, hampered as they were by the lack of power, still did great things, they did them at a cost in time and in sheer toil which we find it hard even to imagine.

THE DISCOVERY OF STEAM

Upon a world so limited came the discovery of the power of steam. Steam altered the whole face of the earth for its inhabitants. By the creation of a new industrial civilization it utterly changed the

conditions of human life. For the first time in history goods could be produced in abundance for all mankind. For the first time in history this abundance could be carried cheaply to all mankind. Steam forced the replacement of individual effort and home industry by industrial organization, for the new steam engine was too big, too expensive, and too complicated to be used except by large numbers of workmen under skilled supervision. Out of steam grew the industrial order and the material civilization of the world today.

What the discovery of steam brought with it was nothing less than a revolution. Because its revolutionary character was not foreseen and provided for, the discovery of steam was followed by generations of fighting on the part of capital to keep, on the part of labor and agriculture to secure, a share in the rewards of greater production. That struggle for economic independence and equality of opportunity is far from settled today. It has produced results of enormous value to humanity, but at enormous and unnecessary cost.

The change from muscle, wind, and water to steam as a source of energy was an epochal change. The change from steam to electricity which is now upon us will not be less so. It behooves us, therefore, not to let it break upon us unawares, not to permit generations of needless bitter conflict to follow it, but to think out the problems it will create, and to take measures in advance to avoid the long train of struggle and disturbance which followed the last great change in industrial power.

Steam might well say of electricity. "One mightier than I cometh, the latchet of whose shoes I am not worthy to unloose," for steam was in fact only the herald of electricity. It is not easy to realize, but electrical development has already proceeded so far that the time is plainly in sight when power for almost every use in the home, on the farm, in the factory, in the mine, and in transportation (by rail at least) will be electrically supplied.

GIANT POWER

Giant Power is a plan to bring cheaper and better electric service to all those who have it now, and to bring good and cheap electric service to those who are still without it. It is a plan by which most of

the drudgery of human life can be taken from the shoulders of men and women who toil, and replaced by the power of electricity.

To the housewife Giant Power means the comforts not only of electric lighting, but of electric cooking and other aids to housework as well. To the farmer it means not only the safety and convenience of electric light, but electric power for milking, feed-cutting, wood-sawing, and a thousand other tasks on the farm. To the traveling public it means the speed and cleanliness of electric transportation. To the dwellers in industrial cities it means freedom from the smoke nuisance and the ash nuisance. To the consumer it means better service at cheaper rates. To every worker it means a higher standard of living, more leisure, and better pay.

Giant Power means all this, but means it on one condition only. That condition is the effective public regulation of the electric industry, which is enlisting new capital and spreading its wires over the United States at a rate wholly unknown before.

Giant Power in Pennsylvania will be mainly coal made power. In spite of the great water powers of the Rocky Mountain Region and the Pacific Coast, and elsewhere, all of which will be in use, Giant Power in America will be for many generations mainly the product of coal. It will create, as the mine workers of Illinois have already foreseen, a new demand for coal not now required, and through this new demand may easily become the greatest factor in solving the problem of full time for our bituminous coal mines.

PROPOSED LEGISLATION

The report of the Giant Power Board points out the main esentials for cheap and abundant universal power service, which is Giant Power. The most important of these essentials, bills to promote which will be presented to you, are:

First: Mass production, with opportunity for by-product recovery.

This is to be secured by Giant Power generating stations of great capacity in or near the coal fields supplying large capacity trans-

mission lines connecting with all other major transmission lines in the State.

Second: The creation of a common pool of power into which current from all sources will be poured, and out of which current for all uses may be taken.

This is to be secured by making these Giant Power companies common purchasers of surplus power from all generating stations in the State and common sellers to all distributing systems in the State.

Third: Free access by every water power and steam generating station to every potential purchaser, which means every distributing system in the State which supplies the consumer.

This is to be secured by making all major transmission lines common carriers of current from the Giant Power companies and other generating stations to any and all distributing systems in the State.

Fourth: Complete, prompt, and effective regulation of rates, service, and security issues.

This is to be secured by fundamental changes in the Public Service Company Law, providing chiefly for measuring the company's right to a fair return upon the stable and easily ascertainable basis of the money prudently invested instead of upon the unstable, slow, and enormously costly process of valuation of the company's property as of each time the rate is fixed. The consent of the companies to this new rate base should be required as a condition of every new charter, merger, or exercise of the right of eminent domain. The Commission should also have power to regulate security issues to correspond with the amount of prudent investment.

Fifth: Rescue of the regulation of electric service from the destruction now threatened by its conversion into interstate commerce, which will be beyond the control of the states and has not been regulated by Congress.

This is to be secured by compacts among the States consented to

by Congress, as allowed by the Constitution of the United States, or failing that, by Congressional legislation.

Sixth: Systematic extension of service lines throughout the rural districts.

This is to be secured by farmers mutual companies and by rural electric districts, each authorized to construct and operate distribution systems, and each empowered to tax and borrow money. Both the mutual companies and the districts should be served on an equality with all other distribution systems by current from the Giant Power companies or any other generating stations, to be delivered over the common carrier transmission lines. The existing companies by the annual expenditure for ten years of less than 3 per cent of their present construction program could build lines reaching 50 per cent of all farms in the State. But their almost complete failure to bring about rural electrification makes legislative relief imperative.

Giant Power versus Super Power

Giant Power and super-power are as different as a tame elephant and a wild one. One is the friend and fellow worker of man—the other, at large and uncontrolled, may be a dangerous enemy. The place for the public is on the neck of the elephant, guiding its movements, not on the ground helpless under its knees.

Giant Power seeks the cheapest sources of power, and hence the cheapest rates. It proposes to create, as it were, a great pool of power into which power from all sources will be poured, and out of which power for all uses will be taken. It is the pooling of supply—not the disposal of surplus—and the chief idea behind it is not profit but the public welfare.

Super-power, on the other hand, is the interchange of small quantities of surplus power at the ends of the distribution wires of each system. Its principal object is profit for the companies—not benefit for the public—and it is on the way to being realized with a rapidity which it is difficult fully to understand. If we are to have Giant Power instead of super-power the time in which to make sure of it is very short.

The main object of the super-power idea is greater profit to the companies. The main object of the Giant Power idea is greater advantage to the people. Giant Power will assure vastly better service and vastly cheaper rates to the consumer, and through effective public regulation, it will set aside the threat of the most dangerous monopoly ever known.

PUBLIC REGULATION

The regulation of any public utility is, and must always be, a compromise. The companies naturally object to every provision for the protection of the public that will interfere to any extent with their freedom to secure their own rates and provide their own regulations, or which will make their investments less profitable, or capital less easy to obtain. The public naturally would like the best of service at the minimum of cost, or at no cost at all.

Neither extreme is possible. For the safety and welfare of the people, there must be restrictions. At the same time, these restrictions must be such as to permit the companies to operate their business successfully, to pay a good but reasonable return upon their invested capital, and to secure additional capital as needed for new enterprises or for expansion.

Electric energy for light, heat, and power is, like the telephone, a natural monopoly. We cannot with safety regard it as a mere service and therefore free from the control of the Interstate Commerce Commission when it crosses State boundaries, as some big electric men would have us do. We must deal with it as a commodity, and therefore suject to such regulation. In any case, being a natural monopoly, it cannot be regulated by competition. Therefore it can only be regulated by public control, and that control, to be effective and to endure, must be fair to the companies, to the investors, and to the general public.

Public control over the electric monopoly may be of several different types. It may be exercised by the individual States; it may be exercised by the Federal Government; it may be exercised by a combination of State and Nation; or it may be exercised by public ownership.

The Giant Power plan takes no account of public ownership. It proposes to deal with facts as it finds them, and does not even raise the question. It must and does, however, take most careful account of the form of regulation best fitted to cope with the gigantic electric monopoly which is plainly in sight.

Electric Consolidation

There is already advancing with immense rapidity, a consolidation of companies engaged in supplying this universal source of power which has already far transcended State lines, and has in many respects reached national proportions. The situation which this consolidation clearly foretells is like one in which every source of steam power in America should be under the control of a single monster corporation. In the face of such a concentration of capital and power the States and the Nation can maintain their industrial freedom and ability to govern themselves only through the medium of effective public regulation.

The time is almost here when electric utility companies will be interconnected all the way from Chicago to the Gulf, and from the Atlantic Coast to the Great Plains. Already a single dispatcher (controlling not trains but current) gives orders for the disposal of the power of several interconnected electric systems. Leaders of the electric industry do not hesitate to forecast interconnection in the near future over all the United States. Whatever the ostensible legal and financial status may be, when such interconnection comes it will bring with it inevitably not only effective unity of service but also effective unity of financial and operating control.

Giant Power and State Control

The plans of the Giant Power Board and the bills submitted to give it effect are both based primarily on the theory of State control. But in considering State control we must remember not only its advantages but its difficulties and defects. It is axiomatic that to be successful and effective the regulating machinery must cover the same ground as the thing it regulates. Regulation of a nation-wide electric combination by the State alone consequently carries with it such inherent difficulties and such disadvantages, from the public point

of view, that nothing less than the wholehearted cooperation of the companies and the States can give it even a reasonable prospect of success.

If cooperation is withheld or impossible, then the next and the inevitable appeal is to Federal regulation. If here again the cooperation of the companies toward securing really effective regulation in the public interest should be refused, then the companies themselves may force the people in self-defense to turn to the only remaining possibility, which is public ownership.

I venture to say that if the people of the United States ever turn to the nation-wide public ownership of electric utilities, it will be because the companies have driven them to it. It will be directly and only because the utility companies have so opposed and prevented reasonable and effective regulation by the States and by the Nation that the only choice left was between servitude to a gigantic and unendurable monopoly and the ownership and operation of that monopoly by the people.

The struggle to secure the Federal Power Act, which regulates the development of water powers in navigable streams and upon public lands, lasted for fifteen years. The circumstances were then such that this delay caused no important losses either to the electric industry or to the public. Both had the time to fight it out.

Today the circumstances are wholly different. The development of the network of interconnected electric lines is so rapid that a delay of even five years in establishing effective public control will bring Pennsylvania and the Nation face to face with the immediate threat of an overwhelming and almost uncontrollable electric monopoly. Delay in this matter can have but one result, and that is the formation of a unified unregulated power trust covering with its lines and its domination the whole territory of the United States.

No one who studies the electrical developments already achieved and those planned for the immediate future can doubt that a unified electrical monopoly extending into every part of this Nation is inevitable in the very near future. The question before us is not

whether there shall be such a monopoly. That we cannot prevent. The question is whether we shall regulate it or whether it shall regulate us.

THE ELECTRIC MONOPOLY

It is almost impossible to imagine the force and intimacy with which such a monopoly will touch and affect, for good or evil, the life of every citizen. The time is fully in sight when every household operation from heating and cooking to sweeping and sewing will be performed by the aid of electrical power; when every article on the average man's breakfast table—every item of his clothing—every piece of his furniture—every tool of his trade—that he himself did not produce, will have been manufactured or transported by electric power; when the home, the farm, and the factory will be electrically lighted, heated, and operated; when from morning to night, from the cradle to the grave, electric service will enter at every moment and from every direction into the daily life of every man, woman, and child in America.

We complain, and with justice, that the cost of food doubles between the farmer who grows it, and the housewife who buys it. But if the cost of electric current only doubled between the generating station and the householder's meter the present rates would be cut into small pieces. Producers of electric current commonly sell it to large consumers for a fifth or a tenth of the price they charge to the head of a family, and for much less than the small industrial consumer pays. It is the small user, the average consumer, to whom the companies charge their highest rates.

Nothing like this gigantic monopoly has ever appeared in the history of the world. Nothing has ever been imagined before that even remotely approaches it in the thoroughgoing, intimate, unceasing control it may exercise over the daily life of every human being within the web of its wires. It is immeasurably the greatest industrial fact of our time. If uncontrolled, it will be a plague without previous example. If effectively controlled in the public interest it can be made incomparably the greatest material blessing in human history.

In the near future electric energy and its products will be as es-

sential, as ever present, and as pervasive as the air we breathe. The unregulated domination of such a necessity of life would give to the holders of it a degree of personal, economic, and political power over the average citizen which no free people could suffer and survive.

The very existence, for example, of industries upon which the prosperity of Pennsylvania is based might be endangered by discrimination in favor of other states. This is no fanciful illustration, for the industries of Switzerland are suffering now from just such discrimination by Swiss power companies in favor of German, French, and Italian manufacturers.

The situation is almost magical in its boundless possibilities for good or evil. On the good side, it is as though a beneficent power were about to shower upon us gifts of unimaginable beauty and worth. On the bad side, it is as though an enchanted evil spider were hastening to spread his web over the whole of the United States and to control and live upon the life of our people.

No such profound change in economic life is possible without profound changes in law and government. It is the part of statesmanship by foresight to make these changes easy, and to take such account of the mistakes of the past that we shall neither pervert the possibilities nor disappoint the legitimate hopes with which we enter the new era of electricity.

THE GREATEST ECONOMIC QUESTION

What the new civilization to which Giant Power is leading will actually become no man can yet foretell. Steam brought about the centralization of industry, a decline in country life, the decay of many small communities, and the weakening of family ties. Giant Power may bring about the decentralization of industry, the restoration of country life, and the upbuilding of the small communities and of the family. In this hope of the future lies the possibility of new freedom and great spiritual enrichment of individual life.

Men can use steam power only where it is generated. That is why steam has concentrated vast numbers of people in industrial

cities. In a steam-driven civilization the worker must go to the power, but in an electrically-driven civilization the power will be delivered to the worker. Steam makes slums. Electricity can replace them with garden cities.

Next to a supply of natural resources sufficient to feed, clothe, and shelter our people, this is the greatest of the economic questions which face the human race. I do not raise it. It has raised itself. But having forced itself upon us, there is but one course we can properly pursue: That is to look it squarely in the face, estimate its possibilities for good or evil, and address ourselves like men to the vast problem of adjusting the growing power of electricity to the growing needs of humanity, remembering that in any solution fit to last and capable of lasting the public good must always come first. Giant Power is the best answer to this gigantic problem that has yet been proposed.

This much is certain—that if we control it instead of permitting it to control us, the coming electrical development will form the basis for a civilization safer, happier, freer, and fuller of opportunity than any the world has ever known.

No subject has come before you at this session, nor will any come, that holds within it so vital and far-reaching an influence as this over the daily life of the present and future men, women, and children of Pennsylvania, and of the whole United States. For good or evil, for economic freedom or industrial bondage, this change is upon us. What it shall bring depends upon ourselves. Of a truth we are in the valley of decision.

As Pennsylvania and the Nation deal with electric power so shall we and our descendants be free men, masters of our own destinies and our own souls, or we shall be the helpless servants of the most widespread, far-reaching, and penetrating monopoly ever known. Either we must control electric power, or its masters and owners will control us.

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AN ACT

Providing for a giant power survey; creating a Giant Power Survey Board; defining the powers and duties thereof; requiring officers, departments, commissions, and other agencies of the Commonwealth to give information thereto; and making an appropriation.

Section 1. Be it enacted, &c., That the Governor, the Attorney General, the Commissioner of Forestry, the Secretary of the Water Supply Commission, the Chairman of the Public Service Commission, the Secretary of Agriculture, the Commissioner of Labor and Industry, the State Geologist, a Deputy Attorney General, to be designated, from time to time, by the Governor, and a competent engineer, to be designated, from time to time, by the Governor, are hereby created a Giant Power Survey Board, hereinafter called the board. The Governor shall be chairman of the board.

Section 2. It shall be the duty of the board to undertake an outline survey of the water and fuel resources available for Pennsylvania, and of the most practicable means for their full utilization for power development, and other related uses; also to recommend, in outline, such policy with respect to the generation and distribution of electric energy as will, in the opinion of the board, best secure for the industries, railroads, farms, and homes of this Commonwealth an abundant and cheap supply of electric current for industrial, transportation, agricultural, and domestic use. The board shall investigate the practicability of, and make recommendations concerning, the establishment of giant power plants for the generation of electricity, by fuel power, near coal mines; the transmission and distribution of the electric energy so and otherwise generated throughout the Commonwealth, the saving and utilization of the by-products of coal, to be consumed in such giant power and other plants; the electrification of railroads; the generation of electrical energy by water power; and the coordination of water power and fuel power development with the regulation of rivers, by storage and otherwise, for water supply, transportation, public health, and recreation, and other beneficial uses.

Section 3. In making its investigations and reports, the board shall make use of all available information heretofore collected by the Commonwealth, and all other published, or otherwise readily obtain-

able, information within the scope of its inquiry. Every officer, department, commission, and other agency of the Commonwealth, possessing such information, shall furnish the same to the board when and as the Governor may, from time to time, direct.

Section 4. It shall be the duty of the board, in its investigations and report, to study and consider the best practicable utilization of streams for navigation, water supply, purity of waters, river regulation, and flood prevention, in relation to power; and both as to waters and as to the generation and distribution of electric energy, to keep in view the mutual interests of this Commonwealth and other States; and to outline plans for the interchange of electrical energy with all other States within the practicable transmission distance.

Section 5. The engineer designated as a member of said board shall be paid such compensation as shall be fixed by the Governor of the Commonwealth. The other members of the board shall serve without additional compensation.

Section 6. The report of the board shall be submitted to the General Assembly at the opening of the regular session in January, one thousand nine hundred and twenty-five.

Section 7. The sum of thirty-five thousand dollars ($35,000.00) is hereby specifically appropriated for the payment of the compensation of the engineer, from time to time, designated as a member of the board, the compensation of necessary technical, clerical, and other assistance, the purchase of necessary supplies, the rent of necessary quarters in Harrisburg and elsewhere, necessary travel of the members of the board and its employes, their necessary subsistence when absent from their regular places of employment, necessary printing, and all other necessary expenses incurred in the performance of the duties imposed under this act.

APPROVED—The 24th day of May, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 240.

CLYDE L. KING,
Secretary of the Commonwealth.

Report of the Giant Power Survey Board to the General Assembly of Pennsylvania

To the Honorable the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met:

The Giant Power Survey Act of May 24, 1923, P. L. 449, placed upon this Board two tasks: An outline survey of the facts; and the recommendation of a policy that will "best secure for the industries, railroads, farms and homes of this Commonwealth an abundant and cheap supply of electric current." The survey and conclusions upon the facts are embodied in the Director's report herewith transmitted and the accompanying technical papers. Having considered the facts so found in the light of sound economic principles, after inviting suggestions from outstanding men connected with the public service electric industry in Pennsylvania, we have deduced and here recommend the main outlines of policy and refer for details to Mr. Wells' paper "Proposals for legislation" which follows the technical reports.

Public power policy must, in Pennsylvania, be concerned chiefly with electric current produced by steam from the rich bituminous coal deposits in the Western part of the State. Water power supplied only 11 per cent of the eighteen billion kilowatt hours consumed in the State in 1922, and this percentage must decrease notwithstanding additional quantities that will be brought in from hydro-electric sources beyond our borders and the more intensive development of our own waterpowers which is beginning under the sound legislation of 1923. This legislation has worked well but should be supplemented in minor particulars.

The most important legislative stimulus to intensive water power development would be a statute to put beyond a doubt the legality of the merger and consolidation of hydro-electric and steam-electric generating companies under proper restrictions. This we recommend.

Turning then to the generation of electricity by steam: The essentials are five in number, namely:

1. Adequate public agencies obligated to a scrupulous regard

for investors' rights as the surest means of attracting the constant stream of new capital necessary for rapid expansion, but adequately empowered to control and guide this stream toward the social ends easily within reach.

2. Mass production, which means "abundant and cheap" production, at the sources of raw material.

3. Mass transportation, which means "abundant and cheap" transportation, to all parts of the Commonwealth by an integrated system of transmission lines.

4. Effective, simple and stimulating regulation from the coal mine to the power consumer, which means the passing on of the abundance and cheapness to him.

5. Fair and justly regulated interchange of power with other states, which means increased abundance and cheapness.

No one of these essentials now exists in fact or is adequately provided for by our law.

1. For the adequate public agencies we recommend:

(a) The creation of a permanent Giant Power Board in the Department of Forests and Waters to carry on the study of the problem and to direct the application of the natural resources (coal deposits) to state-wide electric service through a competent technical staff, with an appropriation of $150,000 for the first fiscal biennium. The Board should have power to establish standards of equipment for the electrification of steam railroads in Pennsylvania.

(b) Such enlargement of the powers of the Public Service Commission as will enable it to control adequately at all points the financial and commercial operation of electric facilities. The particulars are given under the fourth essential below.

2. To secure the cheapness and abundance of mass production in the coal fields, with the added economies of by-product recovery, we recommend:

(a) Legislation authorizing the incorporation of giant power generating and giant power transmission companies empowered to do the following things, if and as prescribed in writing by permit from the Giant Power Board, namely: The generating companies:

> To construct and operate in the coal fields steam electric stations of not less than 300,000 kilowatts capacity (the minimum size limit indicated for profitable by-product recovery);
>
> To mine coal;

To sell, as an incident to the electric generating business, coal more suitable for by-product recovery elsewhere than in the electric generating station;

To appropriate by condemnation process the right to mine coal on specific lands not to exceed an area reasonably estimated to be sufficient to supply the generating station for not more than 50 years, just compensation to be fixed at the time of appropriation in the form of royalty and secured before the taking;

To make and sell coke, gas, other by-products of coal and chemicals;

To sell at wholesale electric current to public service electric companies for distribution by them in Pennsylvania and for transmission to other states under compacts negotiated as recommended in Section 5, paragraph (e) of this report;

To purchase surplus current from other generating stations.

The giant power transmission companies should be common carriers of the current purchased and produced by the giant power generating companies. For this purpose they should be empowered to operate giant power transmission lines of not less than 110,000 volts capacity on locations so fixed by the Giant Power Board as to secure the best inter-connection with and service to other common carrier transmission lines; for such transmission lines to purchase and condemn rights of way and to occupy and use under permit strips of land belonging to the Commonwealth designated by the Board or acquired in fee simple by it through purchase or condemnation. The cost of acquisition could probably be met from year to year without the use of the State's credit and the preliminary work of location would preclude any expenditure under this head during the next fiscal biennium.

(b) That the Giant Power Board be authorized to issue permits for the construction and operation of giant power generating stations and transmission lines, for the conduct of by-product and other incidental business, and for occupancy and use of the lands of the Commonwealth in such land strips for transmission lines, gas pipelines, oil pipelines and other appropriate uses. Permits should be limited to a maximum period of 50 years and conditioned upon the right of the Commonwealth, or another permittee designated by the Commonwealth, to take over and operate the works at the expiration of such period upon repayment to the permittee of the money prudently in-

vested on the faith of the permit. For the right to occupy and use lands of the Commonwealth the permit should fix an annual charge with a view to amortizing the cost of the land strips within not more than 50 years.

3. To secure cheap mass transportation throughout the Commonwealth we recommend, in addition to what has already been said about giant power transmission lines:

(a) That all other public service power business be segregated into three separate classes: (1) major generation; (2) major transmission; and (3) distribution, including minor transmission; also that no corporation be allowed to do more than one of these three kinds of business. For the dividing line between major and minor generation we recommend a capacity of 25,000 kw., and for that between major and minor transmission a capacity of 50,000 volts or 25,000 kw. whichever is the greater.

(b) That the Giant Power Board be required to divide the state into transmission districts on the basis of present facilities and future needs as they may arise or be foreseen from time to time; that every major transmission system be constituted a common carrier for the transmission district in which it lies with the duty of taking electric current of standard voltage and frequency from all public service generating stations (including hydro-electric stations) in the district, and delivering it to all consignees which are public service distributing systems in the district, on terms subject to regulation by the Public Service Commission. With the approval or on the order of the Commission and, on terms thereby fixed, exchange of current with the transmission lines of other districts should also take place.

(c) That two new classes of distribution systems be authorized by law,—rural electric districts and mutual electric companies. The districts should be created with power to furnish current to their inhabitants upon the favorable votes of a sufficient majority of inhabitants and of the owners of a sufficient majority of the acreage; also with power to tax, assess benefits and damages, finance construction work, etc. Mutual electric companies should be formed by the voluntary association of consumers. The districts and the mutual companies should be served by the major transmission lines of the district within which they lie on equal terms with other distributing systems and

should have made available to them expert advice and guidance from the State College.

4. To secure effective regulation that will pass down to the consumer the cheapness and abundance of mass production and mass transmission, in addition to the control provided by the giant power company permits and the control of condemnation above mentioned, we recommend:

(a) That the powers of the Public Service Commission be enlarged to include, as to electric power, the regulation and reformation of:

Contracts for construction, lease and management;

Contracts of brokerage or agency in respect of procuring contracts of construction, lease or management;

Contracts, facilities, service, prices and rates between common carrier power companies and all others from and to whom they are authorized or required to receive and deliver current as above or hereinafter recommended;

Accounting as to all matters mentioned in this discussion of regulation;

Future security issues including the price, not less than par, at which issued;

Maintenance of facilities with due provision for depreciation, amortization and other proper reserves.

(b) That the basis of rate regulation for giant power generating and transmission companies be the amount of money hereafter prudently invested therein.

(c) That as to all other public service generating companies, transmission companies, and distributing companies, hereafter created or merged, including owner and lessor companies or either of them as well as operating and lessee companies, or either of them, and as to all other power companies hereafter exercising the right of condemnation, the basis of rate regulation shall be the amount of money prudently invested after January 1, 1926, plus the value as of that date of all property then used and useful in their public service; that acceptance of this rate base, in the form required by the Public Service Commission, shall be a part of the application for and a condition of every charter, merger or consolidation hereafter issued or authorized; that like acceptance shall be part of every application hereafter made for every preliminary finding of necessity for such condemna-

tion, and shall for all purposes be deemed to be a condition precedent to, and to have been agreed to before, every taking by such condemnation for public use hereafter made with or without such preliminary finding.

(d) That no securities shall be hereafter issued by any giant power generating or transmission company or by any other public service power company without the prior approval of the Public Service Commission. All stock hereafter so issued shall have a fixed par value approved before issue by the Public Service Commission upon a finding that the total par value of any such issue is not in excess of the money which has been or is to be paid for the same at the time of issue, or in excess of the value of the property or services exchanged or to be exchanged for the same at the time of issue, and that the application of such money or property made or proposed constitutes a prudent investment.

(e) That rates, prices and transmission charges imposed by Giant power companies, common carrier transmission companies, and other public service power companies shall be so regulated that the rates of any company as a whole shall provide a sufficient reasonably estimated return to attract into the enterprise new capital in sufficient volume to meet the needs of its public service duty, and if they do as a whole so provide no part of them shall be deemed to be confiscatory. The acceptance of this principle should hereafter be a part of every application for and a condition of every charter, merger, consolidation, exercise of the right of eminent domain, and authorization for the issue of securities, as above recommended with respect to the adoption of the prudent investment rate-base.

(f) That rates of distributing companies operating high-cost generating stations and desiring to substitute cheaper current delivered by a common carrier transmission company may be fixed by regulation to provide, so far as necessary, for the amortization within a reasonable time of all or part of the generating equipment to be disused.

(g) That the Public Service Commission be empowered to authorize or reasonably require the extension of any distributing system, including minor transmission lines, to any unserved territory within the same transmission district, notwithstanding that such unserved territory is within the territorial charter limits of another company.

(h) That the power of the courts to review the proceedings, findings and orders of the Public Service Commission be by statute reduced to the lowest terms consistent with the limitations of the State and Federal Constitutions.

5. To secure fair and justly regulated interchange of electric current with other states we recommend:

(a) That corporations generating, transmitting, or distributing electric current in Pennsylvania be prohibited to distribute current in another state at retail except to present customers in quantities fixed by existing contracts or to new customers in quantities not greater and at present points of delivery.

(b) That a like prohibition be extended to deliveries in another state at wholesale over minor interstate lines (i. e. those of less than 50,000 volts or 25,000 kw. capacity) with like exceptions as to deliveries made over existing minor lines to present customers in quantities fixed by existing contracts or to new customers in quantities not greater and at present points of delivery.

(c) That a like prohibition be extended to wholesale deliveries in another state over existing or future major interstate lines which shall not have been authorized by permit from the Giant Power Board in pursuance of an interstate compact as recommended below, with like exceptions as to deliveries over existing major lines not so authorized; that the enlargement of existing minor interstate lines to the capacity of major lines without such permit be prohibited; and that the construction of new minor interstate lines be absolutely prohibited.

(d) That existing contracts by any such corporation being a public service company, or by any other entity whatever defined by the laws of Pennsylvania as a public service company, for the delivery in another state of current transmitted or conveyed thither from Pennsylvania, shall be subject to regulation and reformation by the Public Service Commission of Pennsylvania to prevent discrimination in facilities, service or rates in favor of customers in other states and against customers in Pennsylvania; also that future contracts of like kind by all such public service corporations or entities, for delivery over lines not authorized by permit as recommended below be prohibited, except contracts renewing existing contracts without increase of the quantity to be delivered, and except those for continuing delivery without increase of quantity to existing customers or at existing

points of delivery; also that such future contracts not so prohibited be subject to regulation and reformation as above recommended for existing contracts.

(e) That the Giant Power Board be authorized to negotiate with the representatives of other states compacts for ratification by the legislatures of the respective states and for approval by Congress under Article I, Section 10, paragraph 3 of the Federal Constitution, for the regulation of interstate electric transmission on principles of mutuality, equality, justice and efficiency; also to grant permits for the construction of major interstate lines under such compacts.

Respectfully submitted,

GIFFORD PINCHOT, *Governor*
GEORGE W. WOODRUFF, *Attorney General*
ROBERT Y. STUART, *Sec'y Forests and Waters*
WM. D. B. AINEY, *Chairman, Public Ser. Comm.*
FRANK P. WILLITS, *Sec'y of Agriculture*
RICHARD H. LANSBURGH, *Sec'y Labor and Industry*
GEORGE H. ASHLEY, *State Geologist*
PHILIP P. WELLS, *Deputy Attorney General*
ROBERT H. FERNALD, *Engineer.*

Advisory Committee to the Giant Power Survey Board

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WM. ALLEN WHITE, ... Kansas

General Report

By Morris Llewellyn Cooke,

Consulting Engineer and Director of the Giant Power Survey

Electrical development especially as to the art of transmitting current in large volume great distances practically without loss has brought the Commonwealth to the threshold of momentous changes in our industrial and transportation technique which will vitally affect conditions of life in both urban and rural areas. The quantity of electric current now used for heat, light and power is such that in view of our present ability to integrate the generating—transmitting—distribution system at least on a state wide basis highly significant economies are brought within range. This makes possible not only a widespread distribution but a revolutionary increase in the use of electricity in factory and in home, on the farm and in transportation. Plans for the immediate construction in the Eastern part of the State of a network of 220,000 volt lines unleashes all the potentialities of Pennsylvania as a power producing and power consuming state.

If these forward steps of the electrical industry, almost necessarily involving far reaching social and industrial realignments, are to be brought about so as to effect the greatest benefits to the largest number of people it will be only because the Legislature and other public agencies have sensed the problem and provided adequate public leadership. Too frequently heretofore society has drifted into a new set of conditions rather than followed a studied route. In this instance it can be predicted with a fair degree of certainty as to just how electricity during the next two or three decades can be made to minister to the needs of the social order. For the Commonwealth and its people to realize actually on the opportunity will require far sighted planning. Fortunately, the margins of profit—present and prospective—are such as make it possible for the electrical industry to adjust itself to any public program without any diminution in prosperity. The development of any ultimately satisfactory plan will

require the combined effort and clear thinking of the State and the industry and our people generally.[1]

REGULATION OF ELECTRIC SERVICE

Of the goods and services which are produced for the ultimate consumer some are supplied (a) by private business operating under competition, (b) some directly by the Government and (c) some by private business (sometimes referred to as "quasi-public") under regulation involving varying degrees of public control. In Pennsylvania the generation, or manufacture, of electricity, its transmission over high tension lines and its distribution to users comes within this last classification. As such it comes under the control of the Pennsylvania Public Service Commission or to use the technical term it is "regulated" by it.[2]

As the regulation of steam railroads has now because of Federal legislation very largely passed to the Interstate Commerce Commission the electric light, heat and power companies together with electric railways have become the major concern of our state regulatory bodies as is shown by the following table. [3]

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[1]Giant Power objectives can be summarized as follows:

1. Large sized steam generating stations—with capacities as a rule of not less than 650,000 H. P. in a given locality to be
2. Located at or near the mines—and supplying current to
3. Trunk transmission lines reaching 220,000 volts.
4. An integrated system of supply and transmission and of distribution.
5. Full development of water powers.
6. The pre-treatment of coal for the recovery of its by-products.
7. Trunk line railroad electrification.
8. Electric service for the rural population.
9. Material reductions in rates especially to the smaller consumer and at least in proportion to the reduction in cost.
10. The public direction and supervision of the great new development in the general interest.

[2]The only exceptions to this rule are our municipally owned plants—some of which buy part or all of their current from central stations.

[3]From "Public Utility Regulation" published October, 1924, by the Ronald Press Co., 20 Vesey Street, New York.

Utility	Capital (Billions)	Annual Business (Billions)
Steam railroads 1921	$19	$5½
Electric light and power companies (private), and electric railways (1917)	8½	1¼
Telephone and telegraph companies (1922)	2	¾
Gas companies (mfg. gas.) (1919)	1½	1/3
All others	2½	11/12
	$33½	$8¾

There is a growing feeling that with the greatly increased use of electricity just ahead of us and in view of the ultimate consolidation of the companies supplying it a private interest with entirely too much power will have been created[1]—unless we can develop an effective technique of regulation. This feeling has been voiced in such headlines as "Giant Power—Aid or Master," "The Future of Giant Power—tyrant—servant or coordinator," "Giant Power—Private Monopoly or Public Service."

If the public is actually to enjoy the social gains included within our conception of Giant Power, regulation must be administered so that economy and efficiency in the conduct of these great electric utility properties may be both encouraged and required and a reasonable share of the reduction in costs resulting from large scale production passed on to the consumer in reduced rates. It should be remembered that regulation at present affords almost no incentive to efficiency. The influence toward better methods exerted by competition in private industry has been largely eliminated among utilities and thus far nothing has been found to take its place. With rates based theoretically at least on what a service costs and with almost no reference to what it *should* cost there is no very strong urge for a service company to pioneer in any large way.

The Advent of 220,000 Volt Transmission

Plans lately announced for the construction of a network of

[1]Fred R. Low, Editor of *Power*, retiring President of the American Society of Mechanical Engineers said in his Presidential Address: "Power is of such vital and increasing importance that its control would give its possessor a mastery over his fellows and opportunities for tyranny and extortion possessed by no autocrat of any previous empire, visible or invisible, feudal or industrial. The people may well be concerned by any gesture in that direction."

220,000 volt lines in Eastern Pennsylvania which it may be inferred will more or less immediately be extended into New Jersey and ultimately into New York suggest a startling effect on the work and authority of our Pennsylvania Public Service Commission.

Recent decisions of the U. S. Supreme Court indicate that energy in the form of gas[1] or electric current passing from one state to another and disposed of at wholesale constitute interstate commerce in the sense that it is wholely subject to national regulation if it is to be regulated at all. Under these decisions state regulation may easily lose control when current crosses State borders in such volume as will be made possible by 220,000 volt transmission. It is probable that our State Commission has already lost the right to regulate rates and service as to current now crossing State lines.[2] At present approximately 7 per cent of the whole volume of current generated in the state is transmitted out of the State and of the whole volume supplied by our central stations approximately 8 per cent is generated outside of Pennsylvania. If our States are to retain the right to regulate prices to users some way must be found by which to disassociate the obviously interstate phases of generation and transmission from distribution which is more local in its character and therefore may possibly be conducted so as to escape the interstate commerce provision of the U. S. Constitution.

The system of regulation whether administered by the Federal or State authority represents a compromise between the waste and disorder inherent in the former competitive operation of these properties on the one hand and complete public ownership and operation on the other. The problem of the control of a consolidated and integrated electric industry will promptly test the adequacy of regulation. If the industry should for any reason get beyond the reach of effective regulation any discussion of a technical development in the public interest becomes well nigh futile. Hence the insistence with which this phase has been discussed. State and nation have faced few questions more momentous. It is believed that the legislative proposals to be made by the Giant Power Survey Board to the Legislature

[1]See Missouri *vs.* Kansas Natural Gas Co. Decided by U. S. Supreme Court, May 26, 1924.

[2]For schedule of all transmission lines crossing our State borders see Appendix C-III.

are fundamental to effective regulation and to the continued prosperity of the industry.

Moving in the direction of broader public control of this industry, at the 1923 session of the Legislature acts[1] were passed (1) indicating the intention of the Commonwealth to hold control in perpetuity of natural power resources over which it now has control, and (2) giving to the State the opportunity of re-capture at the end of 50 years at the prudent investment in the case either of (a) a dam permit for development of State power resources, or (b) a dam permit for the storage or cooling of water for steam generation of public service electric power.

Objectives of the Survey

Assuming well nigh universal electrification as a factor in the social economy of the relatively near future the "outline survey" or reconnaissance of the Giant Power Survey has had two objects—first, the accurate picturing of the present state of electrical development in Pennsylvania; and, second, the study of those steps technical, educational, financial, legislative and otherwise through which the transition to that higher degree of electrification now recognized as possible may be expedited, and accomplished with minimum wastage and with the largest possible gains to society.

Great Growth in the Use of Electricity

The most outstanding tendency in the electric industry during the last two decades has been the increase in the volume of the load. This added demand has come very largely from industry and results both from the adaptation of electricity to entirely new uses as well as through the substitution of electrical for mechanical drive.

The output of central stations throughout the United States at five year periods is given by the U. S. Census as follows:

1902 ....2,506,800,000 kilowatt hours[2]

[1]For these so-called Giant Power Acts see Appendix C-VIII.

[2]A "kilowatt hour"—one thousand watt hours—is the unit used in measuring and selling electricity as the bushel is used in measuring wheat or potatoes, the gallon for gasoline, the dozen for eggs or the pound for butter. A 25 watt incandescent bulb giving light equivalent to 20 or 25 candles uses 1/40 of a kilowatt hour if kept turned on for one hour. A kilowatt hour of electrical energy will keep such a lamp going for forty hours.

1907	5,862,200,000 kilowatt hours
1912	11,569,100,000 kilowatt hours
1917	25,438,300,000 kilowatt hours
1922	38,288,300,000 kilowatt hours

The *Electrical World*[1] estimates the output for 1924 as nearly 50 billion kwh. and for 1933 at 126 billion kwh.

In 1900 about ten per cent of the total industrial power of Pennsylvania was electric. By 1915 this had increased to thirty per cent of the total and at present it is about sixty-five per cent. If this rate of change continues, within fifteen to twenty-five years the conditions of 1900 will have been reversed, and ninety per cent of the total industrial power will be electrical. There are indications that of the electric power installed each year about eighty per cent represents new construction and about twenty per cent substitution of electrical for mechanical drive.

This modern tendency to abandon steam power in favor of electric power is well illustrated by what has happened in the rebuilding of the devastated regions of France where "roughly, nine times as much electrical power is now used, compared with 1913."[2]

PREPONDERANT IMPORTANCE OF POWER FROM COAL

In the public mind plentiful power means power derived from falling waters. This is not and cannot be the case in the Northeast section of the United States where only about 20 per cent of the power used at present is derived from water. This percentage is never likely to rise above 25 per cent[3] and as the total volume of electrical energy increases the portion derived from water will become less and less of a factor.[4] In Pennsylvania only eleven per cent of the present installed capacity is water power.

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[1]Issue—January 5, 1924.

[2]Lionel Hill in "Coal and Power" Hodder & Stoughton—London, August, 1924. See Technical Rept. No. 2 for more detailed quotation.

[3]Certainly not unless there should be some material change made in the treaty provisions as to the quantity of water permitted to be diverted from the Niagara River.

[4]From "Giant Power and Coal" in the Annals, American Academy of Political and Social Science—January, 1924, the following is quoted:

As a rule in the eastern section of the United States water power is not cheaper than power developed from coal. There are unusual water powers such as afforded by the great drop and volume of the Niagara River which make possible an exceptionally low cost. But as time goes on it will become more and more apparent that our chief reliance for cheap and plentiful power will lie in learning to use coal economically.[1]

Inadequate Size of Generating Stations

The vast increase in the volume of electricity generated by the central station industry has led to the development of large size

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"In the northeastern United States the principal water powers are found in New York, Pennsylvania and New England. The situation within this area can be approximately expressed as follows:

Installed steam power:		
New York		3,750,000 H. P.
New England		3,500,000 H. P.
Pennsylvania		5,500,000 H. P.
		12,750,000 H. P.
Developed water power:		
New York		1,250,000 H. P.
New England		1,300,000 H. P.
Pennsylvania		150,000 H. P.
Undeveloped water power:		
New York		4,000,000 H. P.
Niagara	2,000,000 H. P.	(Treaty allowance only)
St. Lawrence	800,000 H. P.	
Delaware	150,000 H. P.	
Interior Rivers	1,050,000 H. P.	
	4,000,000 H. P.	
New England		400,000 H. P.
Pennsylvania		1,000,000 H. P.
		5,400,000 H. P.

"Thus it will be seen that the only undeveloped water powers which can at all vitally affect the power situation in this district are to be found in New York State and have to do principally with the proposed developments of the Niagara and St. Lawrence Rivers."

[1]The mechanisms for transforming the energy of falling water are now better than 90 per cent effective. Therefore improvements in design will not add materially to the total power derived from this source.

generating turbines—reaching 60,000 kw.[1], with 35,000 kw. units quite common and 40,000 kw. units not exceptional.[2] Curiously enough generating stations in Pennsylvania remain relatively small. The ratings[3] of the twelve largest central stations are as follows:

	Present Capacity kw.	*Expected Capacity kw.*
DUQUESNE LIGHT CO., Pittsburgh		
Brunot Island	119,500	119,500
Colfax	150,000	300,000
METROPOLITAN EDISON CO.		
Reading	79,000	......
PENNSYLVANIA POWER & LIGHT CO.		
Harwood	42,750	50,000
Hauto	70,000	100,000
PENN PUBLIC SERVICE CO.		
Seward	40,000	80-100,000
PHILADELPHIA ELECTRIC CO.		
Chester	60,000	120,000
Delaware	90,000	180,000
Christian St. No. 1	91,000	91,000
Christian St. No. 2	65,000	65,000
WEST PENN POWER CO.		
Connellsville	56,500	56,500
Springdale	112,000	300,000

The size of these plants is especially surprising in view of the fact that the main power plant on the U. S. Battleship Constitution now being broken up at the Philadelphia Navy Yard in accordance with the Disarmament Agreement is rated at 180,000 H. P.[4] With the

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[1]A kilowatt (or 1000 watts) is the equivalent in electrical units of 1.34 horse-power of mechanical power.

[2]Henry Ford in a recent interview announced his intention to build 100,000 kw. units (see *Collier's Weekly*, October 18, 1924).

[3]As reported early in 1924.

[4]Horsepower or "H. P." is so frequently used that many have been puzzled as to just what it means and how the words were originated.

The originator of the term "horsepower" was a Scotch engineer, James Watt (1736-1819), who invented the modern condensing steam engine.

He selected a heavy dray horse, a dozen muscular men and by means of a

economy established not only of large generating units but of large stations it is hard to believe that the average size of these dozen Pennsylvania central stations built on dry land is little more than half the size of a battleship power plant designed to operate on the high seas.

The largest coal burning stations in the world are the Genevilliers plant near Paris, France, capacity 240,000 kw.; the Fisk Street station of the Commonwealth Edison Company in Chicago, capacity 230,000 kw.; and the Lake Shore Station of the Cleveland Edison Illuminating Co. which is slightly larger. The largest power station

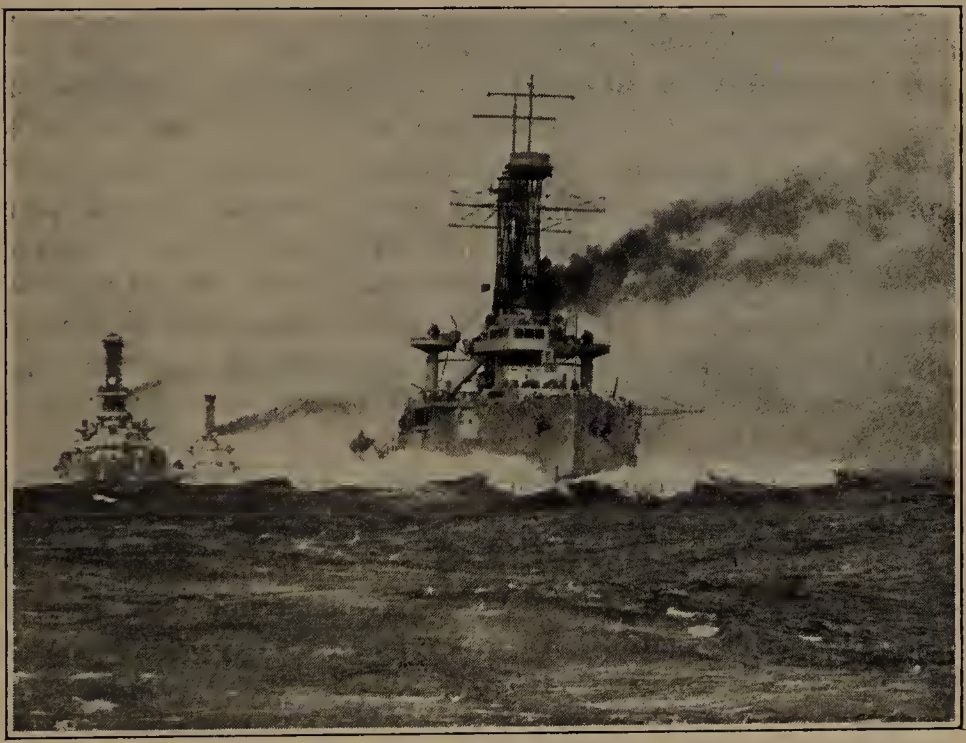

Fig. 1. U. S. Battleship at Sea

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rope and traces, beginning with four men, added man after man pulling against the horse, until he found that when eight men were pulling they balanced the horse's strength.

Then continuing his experiment he found that a horse could lift, by means of block and tackle, 330 pounds at a rate of 100 feet per minute, which, of course, was the same as lifting 33,000 pounds one foot a minute, or 550 pounds in one second; accordingly he designated his steam engines and sold them on that basis. That is known as mechanical horsepower.

From U. G. I. CIRCLE.

in the world is the publicly owned Queenstown-Chippewa water power development on the Niagara River in Ontario which has 270,000 kw. installed.

It has been for years past quite the custom to announce stations of a capacity far beyond anything that has actually been built. For instance, the Philadelphia Electric Company has recently announced the capacity of its proposed Erie Avenue Station as 600,000 kw. or nearly 800,000 H. P.[1] The Commonwealth Edison Company of Chicago places the ultimate capacity of its new Crawford Avenue plant at the same figure.[2] These capacities are approximately those proposed by the Giant Power Survey for mine-mouth plants.

Under the construction policy in vogue in the electric industry power stations are put in service gradually over a period of years. Units and sections are added as the load is built up. Because of a design become obsolete or because of a shift in the load center, but more frequently because it is speculatively more profitable to float securities with which to begin a new station than to complete an old one the larger plants are rarely completed to their designed capacity. Practically all the larger power plants recently constructed have been financed independently of the public utility with which they are associated. The parent company simply contracts to take the output of the generating station and distribute this current within its own territory.

Thus within the industry itself forces are at work tending to separate the generation of current from the business of distributing it to the users. Distribution is recognized as having "service" features and is necessarily attached to a given territory and therefore local in character. Philip Cabot with a long time experience in utility operating in New England advocates not only the separation of distribution from generation and transmission but retaining it in the hands of people residing in the district served.[3] Even though the promoters and operators of electric public utilities are outspokenly opposed to public ownership quite a few of the leaders of the industry have come to see no objection to the use of public credit in the building of generating equipment at water power sites such as Muscle

[1]*Electrical World*—August 16, 1924.

[2]Year Book—Commonwealth Edison Co. 1923, p. 13.

[3]See "National Electric Highways" by Philip Cabot—an article in the Giant Power number of the *Survey Graphic* for March, 1924, p. 581.

Shoals, Boulder Dam and on the St. Lawrence River. This is not only on account of the great size of such projects but because the major expenditures must be made before an adequate load has been built up.

Influence of Exclusive Territorial Rights

The factor which seems to be controlling the size of central stations in Pennsylvania is the system under which the State through corporate charters grants, with the approval of the Public Service Commission, to an electric company the exclusive right within territory fixed by the charter to distribute electric current to its customers, and the resulting practice of limiting generating and transmitting facilities accordingly. While the purpose is to prevent duplication of facilities this practice has acted as a bar to the pooling of the demands for current from the chartered territories of two or more separate companies or the manufacture of this current for joint account.[1] In the absence of such an opportunity to generate electric current for a group of distribution districts the completion of any large size station to its full capacity at one time would necessarily lead to "overproduction" of power.

Interconnections *vs.* Integration

During the War the Government ordered the first interconnection between contiguous electric utility territories in order to permit a more effective use of the current generated through making it possible for one system with an excess of current to dispose of it to a neighbor having a use for it. Recently the number of such interconnections has been growing quite rapidly but with their uniformly small capacity they act rather as a measured insurance against shortage than as a step toward an integrated and unified electric service throughout Pennsylvania. The inter-company agreements under which these inter-connections operate frequently provide such terms as frankly to discourage the exchange of current such as provision for a highly remunerative rate.

Governor Pinchot has said:[2] "By 'inter-connection' is generally

[1]This situation is met in a way by a station at Windsor, West Va., different proportions of which are owned respectively by the West Penn Power Co. and the Pennsylvania & Ohio Power Co.

[2]At the annual convention of the National Electric Light Association at Atlantic City, May 21, 1924.

meant interchange of surplus[1] power between complete generating—transmitting—distributing systems at the common boundaries of their respective territories of distribution. It is usually interchange of such surplus over the outer filaments of their respective webs of transmission lines. Since the voltage or capacity of these lines is not designed for interchange of large quantities of power the connections of the transmission web at the outer boundary of the exclusive territory do not allow for any great amount of power to be exchanged by such interconnection from one system to another. 'Interconnection' of this kind is like the interlacing of leaves and twigs over a street shaded with a row of elms on each side. Only a squirrel can pass from one to the other. Interconnection of this kind exists and is coming to be common practice in the electrical industry. Where there is a series of systems so 'interconnected' current may be relayed from one system to the next throughout the line.

"But when I speak of 'integration' in any territory (whether or no there are in it separate systems having each its exclusive territory of distribution) I mean interchange over trunk transmission lines designed to transmit great quantities of power at high voltage, over great distances so as to give to the whole territory thus integrated the advantage of the cheapest possible electric generation at the lowest possible transmission cost. The primary urge for integration is the quest for the cheapest source of power[2] without regard to boundary lines of territorial distribution. *It is a pooling of supply, not a disposal of surplus.* . . . Such integration does not now exist in Pennsylvania, nor generally in so-called 'super-power' regions in the United States, wherein there are separate generating—transmitting—

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[1]See agreement between Niagara, Lockport & Ontario Power Co. operating in the State of New York, with our own Penn Public Service Corporation, dated Sept. 10, 1924 "for the interchange of surplus electric energy." According to an article "Superpower in Switzerland" in the N. Y. *Nation*, June 25, 1924, all power exported from Switzerland to Italy, France, and Germany goes out as "surplus power."

[2]The streams of France are in flood at different seasons of the year. In the region around Paris winter freshets are common. Streams flowing out of the Alps and the Pyrenees each have their flood seasons. To utilize these cheap sources of power one extensive system of high tension lines for the common use of power companies wherever located is being provided under Government direction.

distributing systems having each its exclusive territory of distribution."

The building of further stations of the present average size is as a matter of fact looked upon by the industry only as an expedient and to meet pressing needs. Transmitted current (i. e. current generated outside the distribution area wherein the current is to be used—except when that territory happens to be the same as that providing the most economic production) is coming to be recognized as the rule of the future. While no announcement has been made as yet it is becoming evident that one of the largest power producing and distributing companies in Pennsylvania is planning to buy a large volume of its base load current, developed from coal, from another company located entirely without its territory. Such an arrangement has been brought about only because the seller company has access to cheaper sources. This constitutes a radical departure in inter-territory relations. When present inhibitions against manufacturing current for the joint account of two or more distribution territories have been removed the economies accompanying large sized stations operating with a high load factor will be realized.

Unnecessary Construction Going On

When the process of consolidating electric properties first began the territories so combined were usually contiguous. In recent years however some of our large holding companies have acquired territorial rights separated from each other by territory assigned to different interests. Therefore in order to join by "interconnections" properties controlled by the same financial interests transmission lines crossing territory assigned to other companies have been built. In some cases this has been strenuously opposed by the interests whose territory was to be crossed. To meet the situation the Public Service Commission has recognized "strip charters"—charters giving the company building the transmission line the right to operate only over a strip of ground 100 feet wide[1]—wide enough on which to cross but obviously too narrow to permit the sale of current in transit. Such a line is comparable to a railroad operating between two points but not permitted to take on or discharge passengers at intermediate stations.

[1] In the pending applications for strip charters for 220,000 volt lines a width of 500 feet is stipulated.

In other instances transmission lines have been unnecessarily paralleled, after the order of the railroading of forty to fifty years ago, in order that each of two companies occupying adjacent territory might keep their respective systems intact. These cases further illustrate the inadequacy and possible wastefulness of "interconnections."

CONSOLIDATION AMONG ELECTRIC SERVICE COMPANIES

During the last few years—especially during 1923 and the early months of 1924 there has been evident in all parts of the Commonwealth a strong tendency toward the merging and consolidation of existing electric service companies and the incorporation of new ones. One summary states that "in 1923, 341 new power companies were organized; 205 companies were sold to 30 other companies; and 88 companies were merged to form 12 new companies." The process seems to have reached a peak in 1923 as Commissioner Stewart states[1] that the P. S. C. approved 363 incorporations of electric companies in that year and 141 in the first 9 months of 1924. Applications for such approval in previous years had been 1919, 147; 1920, 127; 1921, 103; and 1922, 178. The principal reason for this numerical decline recently in incorporations is probably that the territory of the State is practically all allotted. (See large scale map accompanying this report.)

THE BEGINNINGS OF THE ELECTRICAL INDUSTRY

The electrical industry dates back only some forty years, to 1882, when the first generating plant was built to supply current for several hundred 16 candle power bulbs located in less than a dozen buildings on the same block in Pearl Street, New York City. "In the early days people thought of electricity largely in terms of the incandescent lamp. Thus the trade association of the electrical industry still goes by the name of 'National Electric Light Association.' Residence lighting in those early days afforded practically the only outlet for current. But when the electrical industry realized that current usable for light and heat, and especially for power, was really the product of these 'lighting stations' there began a campaign for the elimination of the *isolated* industrial power plant—so called to distinguish it from

[1]See Appendix C VI. "Consolidation in Electric Utility Industry" by John L. Stewart.

a *central* station doing a public service business in power for the benefit of a number of customers. The process was artificially expedited by rates discriminating in favor of power service, so that current was sold on narrow margins and even at a loss, to industrial users, especially those formerly operating their own power plants.''[1]

The Lengthening Transmission Distance

When electric current first came to be used for power in industry the point of use was not far from the generator—never more than a

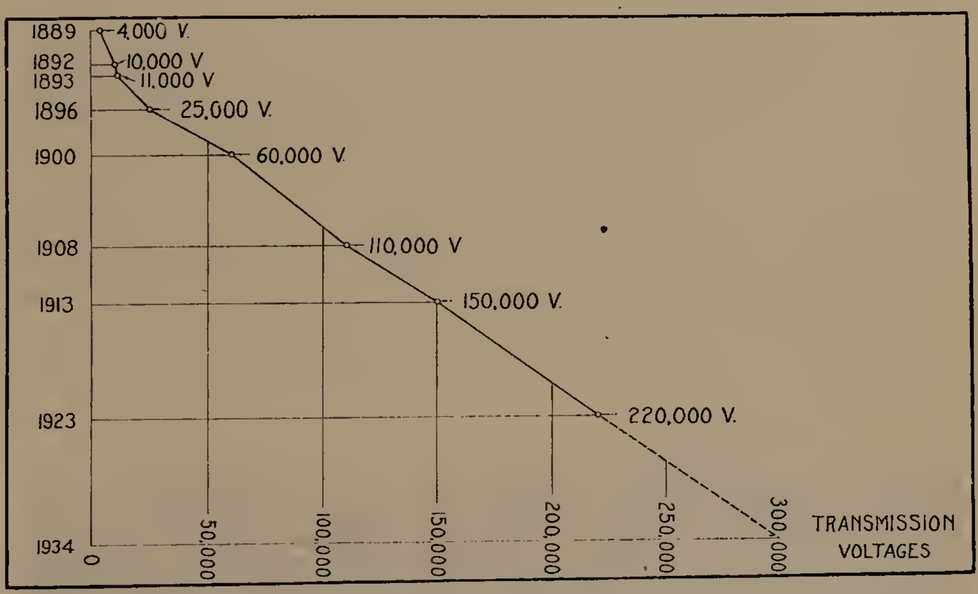

Fig. 2. Curve Showing Increase of Transmission Voltages, Permitting Increases in Transmission Distances[3]

few hundred feet. With the demand for larger and larger volumes of current came the desire to send it greater and greater distances. This gave rise to high tension transmission. Frank G. Baum dates this re-birth of the industry about 30 years back to the opening of an 11,000 volt line in California.[2] This was the logical place for such a development because of the high cost of coal and since California

[1]From "The Long Look Ahead" in the Giant Power Number, *Survey Graphic*. March, 1924.

[2]See page 1, U. S. A. Electrical Power Industry by Frank G. Baum, published 1923; also article by Percy H. Thomas, page 619, *Electrical World*, September 20, 1924.

[3]From *Electrical World* May 17, 1924, p. 998.

is rich in low cost water powers located in almost every instance at considerable distances from the areas of possible use. Two 220,000 volt lines are now in operation in California, and three are about to be built in Pennsylvania: one, running East out of Sunbury on the Susquehanna River, to Siegfried near Allentown; a second, from Siegfried to Hawley tying in the Wallenpaupack (Wayne Co.) water power and touching the Delaware River at Bushkill in Pike County; and the third connecting the Conowingo water power on the lower

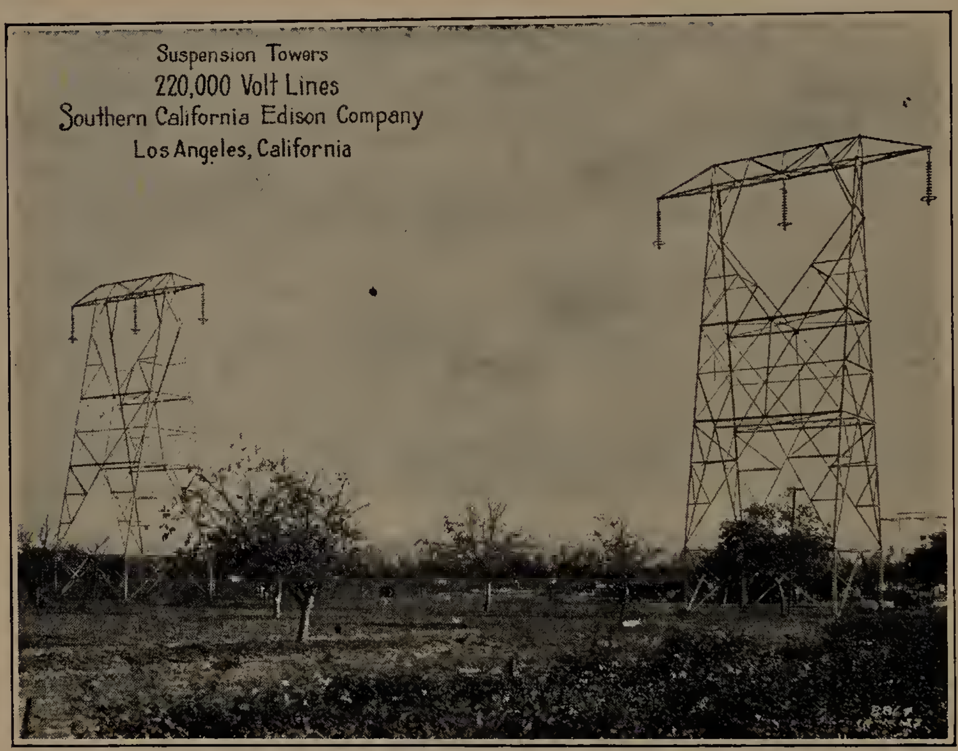

FIG. 3

Susquehanna River just over the line in Maryland with the City of Philadelphia via Coatesville and Norristown.[1]

The reliability of high tension transmission is illustrated by the fact that the City of Berlin, Germany, is now solely dependent for current on the 110,000 volt lines bringing current from mine mouth stations 80 miles away, all standby facilities in Berlin having been done away with. Power generated at Niagara Falls is being transmitted 237.5 miles West to Windsor, Ontario, over a 110,000 volt line.

[1]See application for license before Federal Power Commission.

Under present conditions approximately 30,000 horsepower can be supplied in Windsor with a power loss of approximately ten per cent.

220,000 volt lines are capable of transmitting the current generated by a 500,000 kw. station a distance of 300 miles—or across Pennsylvania—with transmission losses, "shrinkage," not to exceed 10 per cent. In other words our ability to transmit electric energy economically has gone far beyond the point where this factor acts as a bar to the utilization of the cheapest source of energy within the State and to serving current from this Station to customers in every one of the 67 counties.[1]

Integration Will Lead to Uniform Rates

It is common practice for a given company to use uniform rates for the same class of customers and service throughout its territory. With the consolidation of companies the territorial range of rates schedules has constantly widened. Now that current can be sent great distances from the point of low-cost generation to the points of use only artificial barriers, largely legalistic, stand in the way of electric rates fairly uniform throughout the State for the same class of service.

Mine Mouth Power Stations

Shipping coal is economically comparable to shipping corn stalks or sheaves of wheat to the mill when you want meal or flour. The power plant at or near the mine is the thresher which separates grain from straw and chaff. This done, the electric transmission line carries the perfected product with minimum of loss to the distribution area for use on farms and in homes and factories. It is quite obvious why power plants were originally located near the points of consumption rather than at the mines. That the great bulk of generation is still carried on at great distances from the mines is due to a number of influences. The one however which is usually assumed to be con-

[1]Electric energy is now generated and transmitted as alternating current. The recent invention of a transverter permits alternating current to be converted into direct current at a relatively low cost. If this method is confirmed it is believed that transmission costs may be very definitely reduced, as the possible economies in both construction and transmission costs by direct current will be about half those of transmitting alternating current.

trolling is the need for condensing water—found on some of our larger rivers and of course in limitless quantities at the seaboard.

Condensing water is normally required to remove the heat from the exhaust steam. The quantity needed varies widely with its temperature, the mechanical appliances used and other factors. With conditions frequently encountered under American practice as much as 400 tons of water are required for each ton of coal burned. Such relative weights of coal and water suggest why the coal is carried to the water. To develop 100,000 horsepower requires a flow of say 250 cubic feet per second. So a stream as large as the Schuylkill River in mid-Summer must pour through the steam condensers. A river of this size cannot be taken to the mine and few mines are along or under rivers.

But adjustment is possible at a number of points in Western Pennsylvania.[1] On the one hand the low water flow can be increased by flood storage and, in some locations, works permitting the re-use of water may be erected. On the other hand the cost of loading and handling the fuel can be improved and cheapened for the short haul from mine mouth to nearby power station. The cost of coal handling may indeed be reduced to a few cents per ton as compared with several dollars which is not an unusual charge for transporting a ton of coal from Western Pennsylvania to the seaboard.[2]

It is entirely possible that within 20 years we may be using twice the quantity of electricity we are using today. The question may properly be asked if present practice in regard to condensing is continued where will the additional water required for condensing be found except at the seaboard and if the power stations of the future are to be located there will it still be possible to provide the transportation facilities necessary to haul the volume of coal thus required.

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[1]See Technical Report No. 3 "Natural Resources Available for Power" by F. H. Newell.

[2]Typical long ton freight rates for bituminous coal shipped out of Western Pennsylvania are as follows:

From Westmoreland to Philadelphia	$2.84
Connellsville to Philadelphia	3.24
Clearfield to Philadelphia	2.84
Greensburg to Philadelphia	2.94
Latrobe to N. Y. Harbor	3.09
Connellsville to N. Y. Harbor	3.49
Connellsville to Brooklyn	3.62

The Social Economy of Water Storage

All sorts of benefits flow from water storage or water regulation on a large scale, as they do from financial or banking stability. Water is the currency of life and industry. The steadier the supply and demand the greater the direct and indirect economies. By water storage flood destruction may be reduced, water power increased, municipal supplies provided and stream beds flushed out and otherwise purified during the hot Summer days when sewage, mine and industrial wastes are most in evidence. While it might not pay to store water for condensing purposes alone yet the combination of uses, each aiding the other is distinctly profitable to the whole group of uses, industrial, sanitary and recreational as well.

"Artificial" Cooling Gaining Ground

The economy resulting from the use of such great quantities of condensing water may easily be outweighed by other advantages inherent in power plant locations where water in such abundance is not available.[1] The feeling is even encountered in competent engineering circles that under present day conditions too much importance may easily be attached to condensing. However this may be, the two largest plants in Germany—both built during the War—are located at the mines[2] and with a supply of water only adequate to make up for evaporation. The testimony afforded by a municipal plant in Birmingham, England, almost as large as any plant in Pennsylvania, is eloquent in that the site chosen is at the mines even though water adequate for condensing purposes could have been had only 20 miles away. In all three of these stations mammoth cooling towers out of scale with anything in the engineering practice of the United States are used.

With power plants placed at or near the mines it becomes possible to use larger quantities of the low grade fuel and even waste brought to the surface in ever-increasing quantities by the newer mining methods. The less the handling or hauling expense the better it will pay to use the more bulky or inferior coal, high either in ash, bone or

[1]See Appendix C IV, "Water as a Factor influencing Locations of Giant Power Plants" by August Ulmann, Jr.,

[1]Golpha-Zchornewitz plant 144,000 kw. and Trattendorf plant 80,000 kw.

slate. The cost of getting this material up to the mine mouth is as great as that of extracting commercially valuable coal. Used near the mines it may be worth what it cost but it cannot stand an additional railroad freight charge. The City of Prague in Czechoslovakia is now constructing a large power plant about 70 miles distant and at mines producing a brown coal so low in heat units as to be considered entirely unprofitable as an ordinary mining proposition.

FIG. 4. COOLING TOWER AT TRATTENDORF, GERMANY

STOPPING THE WASTE OF BY-PRODUCTS

Giant Power stations at or near coal mines will encourage the processing of the fuel for the recovery of its valuable by-products

before the heat content is utilized in power production. Coking of coal can only be practiced profitably on a large scale hence we have suggested as a standard a 500,000 kw. station utilizing approximately 20,000 tons of bituminous coal a day[1] and located in a neighborhood where a 50-year supply is assured. The Clairton high temperature coal distillation plant of the United States Steel Corporation has been designed to process 25,000 tons of coal a day to provide in part the metallurgical coke required for their blast furnaces, and also gas for steel working furnaces.

Fig. 5 By-Product Coke Works of the Carnegie Steel Co., (Largest Coal Carbonization Plant in the World)

The loss of fuel substance and heating power in conducting any sort of coal distillation, or partial or complete gasification, is not less than 10 per cent and in some commercial processes, 20 per cent or even more. With the process carried on at the mine mouth, this loss is supplied at mine prices, without freight costs.

The high temperature by-product coke oven is thoroughly well established in the metallurgical industries. The various products other than coke resulting, such as ammonium sulphate used for fer-

[1]See Technical Report No. 4 "Pretreatment of Bituminous Coals" by Judson C. Dickerman.

tilizers, tar used in road building, gas and benzol, have become important factors in American industry. Low temperature carbonization and certain gasification methods now advocated as adjuncts of the electrical power industry will result in a somewhat similar line of products.[1]

Our petroleum resources are being consumed rapidly. A future hope for gasoline is oil recovered from coal distillation. Oil can be recovered from coal and gasoline can be made from this oil. Recovery of oil from coal is more feasible than oil from shale. Enough gasoline can be made from coal to run more than half of America's automobiles without jeopardizing power from the same coal, i. e. with but slight reduction in the heat producing capacity of the coal.

The treatment of high volatile coal before combustion has become a prime economic and social necessity.

STEAM RAILROADS AS COAL CARRIERS

Herbert Quick has pointed out[2] the bearing of electricity upon the national transportation problem. Early in 1907, and again during the greater part of 1912 and more emphatically during our second war year—1918—our railroads were unable to handle the freight offerings. On the last occasion they were assisted in using facilities effectively through the exercise by the Government of its full military prerogatives. Quick argues from these experiences that on the next industrial boom the roads will be congested to the point of breaking down. In a way Pennsylvania is the bottle-neck of the national railroad system with her key lines running North and South and East and West. Owing to the way in which the community has crowded up to the present rights of way it is probably not feasible to add new rail lines. Certainly relief can most easily be found through using present facilities more efficiently. As the most effective means to

[1]A station of 500,000 kw. will only require the heat units from approximately 6,000 tons of coal daily, but to obtain this amount of fuel for the power station as one of the by-products of an efficient coal treating plant it is estimated that 20,000 to 25,000 tons daily should be mined and treated. By far the greater proportion of the resulting coke will be too valuable to be used in the power station.

[2]See *Saturday Evening Post* for Feb. 25, 1922, "America, An Experiment in Transportation."—Mar. 4, 1922, "Transportation Possibilities and Impossibilities"—and "Solution of the Railroad Problem" March 11, 1922.

this end Quick urges taking the coal load off the railroads; first by the establishment of mine mouth power plants making it unnecessary to haul fuel to far away power plants and second, by electrifying the roads so as to make it unnecessary to haul coal for their own use. The railroads can then handle a greater volume of higher grade commodities and be operated more effectively because of the greater flexibility resulting from electricity as the motive power. Any such fundamental developments are necessarily brought about gradually thus giving the railroads most likely to be affected an opportunity to adjust themselves to the new conditions.

With the demand for coal localized at the mine and stabilized there will come a better type of coal mining leading to more continuous employment of the miners and other improved conditions. Operators of power plants will be relieved of much of their present anxiety as to the continuity of their fuel supply. It will no longer be necessary to carry large volumes of coal in storage at multitudinous points of use. Our larger cities will be benefited through the doing away in large measure with both the smoke and ash nuisances. Lower plant costs result from power stations near the mines due to both lower land values and to lower construction costs. Pittsburgh being the largest manufacturing center for steel and brick makes the neighboring coal region an especially economical district in which to build by-product stations and power plants in both of which these two commodities are important factors.

Giant Power and the National Defense

The location of power stations at the mines has great military importance[1] in that first, such localities are more easily defended; second, by-product ovens are required in increasing number to provide certain of the constituents of explosives; and third, the integrated system of electrical service which such stations make possible permits the widest geographical and quantity adjustments in supply as may become desirable through rapidly changing military exigencies. Of course this last point has a peace-time bearing in widening the pos-

[1]See article by Major General William Crozier, U. S. A. Ret., formerly Chief of Ordnance, in the Giant Power issue of the Annals of the American Academy of Political & Social Science, March, 1925.

sibility of meeting conditions created by unforeseen circumstances such as droughts, conflagration and calamities of other kinds.

The electricity used in the reconstructed areas of France where the designing and building has been carried on for efficiency only and untrammelled by traditional practice "comes wholly from either (1) colliery plants or (2) coal field power stations."[1]

In addition to the economy resulting from manufacturing the current at or near the mines in Giant Power stations of great size with the recovery of the by-products of the coal, trunk transmission lines of high voltage, and a unified system of lower voltage transmission and distribution lines will make unnecessary 80 per cent[2] of the present investment in standby facilities and will lead to marked improvements in the load, diversity and power factors of the State. Of course the public should participate generously in these savings through reductions in rates. Present margins are ample to put the industry on a cost plus a fair profit basis. Then if regulation can be made to regulate, future economies will be passed on in proper proportion and automatically to the public.

RAILROAD ELECTRIFICATION

It is impossible to discuss electrical integration in Pennsylvania without having in mind its bearing on the future electrification of our steam railroads—especially of trunk lines. In the so-called Super-Power Report[3] it was estimated that 3½ billion kilowatt hours would have been required to handle electrically the traffic of the steam railroads within the State in 1922—something less than 20 per cent of all the power used within the State that year.

But this factor of railroad electrification does not appear at the moment to be urgent. Much more important than pressing for steam railroad electrification is the making sure that, as in France, some

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[1]"Coal and Power"—Hodder & Stoughton—London, England, page 223.

[2]"Through a transmission system of adequate capacity and scope 80 per cent of this idle investment (in standby facilities) could be eliminated. Right there you save nearly $500,000,000." Philip Cabot in *Survey Graphic*, March 1924.

[3]"A Super-Power System for the Region between Boston and Washington," Professional paper 123, Department of the Interior 1921, U. S. Geological Survey by W. S. Murray and others.

public agency approve construction and equipment standards so as to ensure eventually a fully interchangeable system and the avoidance of troublesome voltage, frequency and other variations. It should also be provided that such generation capacity as may be required by the steam railroads is made a part of the State-wide electrical service. In such electrification plans as have already been either executed or proposed, this latter principle appears to be fully recognized.

Carrying Electricity to the Farms

That an almost negligible start has been made on the electrification of rural Pennsylvania is shown by the following table:

Whole number of farms in Pennsylvania	202,250
Number now having public utility service	12,452[1]
Those without public service	189,798
Farms with their own farm lighting plants	11,132
Number without electric service of any kind	178,666
Farms with gas plants	7,085
Farms without modern means of illumination	171,581

There appear to be two chief reasons for this failure of the electrical industry to cope with this part of its problem: first, absorption in meeting the very great and urgent demands for power in the large industrial centers; and second, rate schedules in which farmers were classed with urban domestic consumers. Under this view rural rates were town and city rates *plus* something.[2] This has resulted in a low average consumption of current by those farmers having electric service—used principally for light—and averaging probably less than 50 kwh. per month. Rural rates for this average use range around 15 cents per kwh. Inquiries carried on both in other states and in Europe establish beyond a doubt that given adequate facilities and proper rates the farmer is essentially a power user rather than a light user. On many farms a great deal of power is used. Therefore the farmer is entitled to rates more on the order of

[1]This is an estimate but one materially higher than that furnished by the Pennsylvania Electrical Association.

[2]The *sixth* paragraph of the Rural Lines Code of the National Electric Light Association reads: "Rates for rural service shall be regular city rates plus a rural charge, etc." see *Electrical World*, November 17, 1923.

those given to industrial power users[1] than those given to urban domestic service where current is normally used only for illumination and the relatively light work incident to housekeeping. Rural electrification means more than simply connecting the farms with the distribution system. It means a rate structure so arranged as to encourage a constantly increasing use and rates themselves based on the actual cost of service plus a fair profit. Only by bringing about a large use of current can electric service vitally affect rural life.

Assuming an average use of 100 kwh. per month—somewhat less than the average use of the consumers in Waukesha County, Wisconsin[2]—for 75 per cent of the farms now without service, they would consume over 150,000,000 kwh. per year. This is approximately 5 per cent of the total kwh. sold in the State of Pennsylvania, and approximately 50 per cent of that now sold by public utilities for domestic lighting service.

Our reconnaissance indicates that over two millions of the people of the State are now without access to electric service and of these over 40 per cent can be classed as farm population. From the curves showing the population which can be reached through the construction of different mileages of pole line (See Technical Report No. 5, Rural Electrification, by George H. Morse,) to furnish electric service to approximately 1,300,000 of this 2,000,000 population 40,000 miles of pole line would be required. The construction of 20,000 miles of line—reaching 750,000 population of which 325,000 would be farm population (the occupants of 75,000 farms) would cost something less than $30,000,000.[3] Laid out in a five-year program this would represent approximately 5 per cent of the current annual capital expenditures of the Pennsylvania electric service companies.[4]

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[1]Current rate schedules actually deter farmers from using power as for instance the demand or minimum charge of $1.00 per horse power per month for motors as taken from city practice. In a factory a motor is usually in service a considerable part of each working day. On a farm the use of motors is very intermittent. This is especially the case with the larger motors.

[2]See Appendix B IV, "Studies in Rural Electrification" by G. H. Morse.

[3]The Hydro Electric Commission of Ontario (Canada) report the cost of building one mile of rural overhead line as $1200 when 25 miles are constructed at one time.

[4]The capital expenditures of Pennsylvania heat, light and power companies for 1923 approximated $100,000,000.

Fig. 6. Area Covered by Distribution Lines of the State in Which Electric Service is Available

The black area constitutes 20 per cent. of the total. It is based on the assumption that points from one to one and a half miles either side of a distribution line, which is known to be in existence, can be reached by extensions of moderate cost. Half of this black area, or 11 per cent of the total, is counted as being actually served at the present time

If spread out over a ten-year period it would probably not be much if any in excess of 2 per cent of such expenditures as outlays for capital account in the electrical field are mounting rapidly.

No such problem existed when our electric service companies were first chartered nor in fact when the Public Service Commission was organized in 1911. But if it has now developed that rural electric service is a prime need of the Commonwealth and can be made self supporting if supplied to a very large part of the population now without it, does it not follow that it has become the responsibility of the private corporations given well nigh exclusive rights in the field to provide the means?

THE WIDER DISTRIBUTION OF INDUSTRY AND POPULATION

Any considerable rural electrification will probably result in spreading out our industry, in slowing up the growth of our already over-grown centers of population, and in starting new industrial centers in what are now strictly rural sections. While power is a relatively small item in the whole cost of most products it is an absolutely necessary factor in all manufacturing. The history of industry teaches that most successful undertakings have small beginnings. Henry Ford has recently said:[1] "Industry is going to decentralize. When it does the modern city is doomed. In a small community where a man can have his own garden and the strain of living is not so tense, there is less unrest and less violence, less poverty and less wealth. Besides every man is better off for a period of work under the open sky. I sometimes think that the prejudice and narrowness of the present day are due to our intense specialization. We all need changes and while we cannot afford to loaf around summer resorts, we can escape routine and monotony by labor exchange during slack seasons."

Power widely distributed through sections now devoted exclusively to agriculture may add to Pennsylvania's industrial development and cause the manufactured articles required by the farmer to be made nearer his door with a resulting lowering of costs.

A GIANT POWER INDUSTRY[2]

There does not appear to be any necessary economic association between large scale or Giant Power production of electricity and the

[1]*Asia*—December, 1924.

[2]See Technical Paper No. 6, "A Giant Power Industry" by O. M. Rau.

distribution end of a public electric utility. The generation of current is essentially a mass manufacturing undertaking while the function of an electric public utility is to develop effective and efficient distribution of a commodity, which distribution has always been described by the utilities themselves as "service" and not simply energy. An electric heat, light and power utility functions very largely as a sales organization. The separate financing recently provided for power stations appears as a recognition of the desirability of having production stand on its own feet.

In determining rates to be charged to the great majority of consumers the manufacturing cost of the power itself has long since become of minor importance. Rates especially to the smaller consumers are largely based on what the industry terms "the cost of service" and not on the cost of power. This situation appears to greatly retard a healthy and balanced growth in the use of electricity and prevents the spread of distribution lines especially to farming sections. Rural communities are not interested in the "service" demanded by city folks. Rural rates today are based on a level of "service" which the farmers do not want and which is actually rarely furnished.[1]

Perfect (infallible) service is impossible, yet the point to which perfection is demanded is actually reflected in the rate. A metropolitan district demands as perfect service as human intelligence and effective management can provide. Rural service on the other hand requires the least of such effort for an intensive development. Thus for farmers the manufacturer's cost of power may be very close to the consumer's cost. For suburban and inter-urban consumers the cost will increase depending upon the standard set for service, until when the metropolitan areas are reached, present rates which are based on very great differences between manufacturing cost of power and the sale of this commodity as so-called "service" to the local consumer may even prove to be warranted.

The only logical answer appears to be a Giant Power industry through which power as a commodity is manufactured in enormous volume and then sold in bulk at cost plus a manufacturer's profit to any one capable of using a sufficient quantity (comparable to a stand-

[1]Such as: (1) assured continuity of service, (2) instantaneous response to trouble calls, and (3) provision against voltage variation.

ard package in other manufactured products) as to warrant delivery. Thus our service companies will be relieved of the necessity for providing generating stations and can confine their efforts to attending to the needs of the consumers assured that the power they distribute is obtained at a figure at least as low as it could be secured from a manufacturing plant of their own or one from which they contracted for the entire output.

To produce power at the lowest cost mass production in the full meaning of that term must be practiced all the way from the face of the coal seam to the distributor's sub-station. This means not only large scale production carried on at the most advantageous sites and under the most favorable conditions but practicing every economy, "Ford methods" in short. The development of such a Giant Power industry can be accomplished through the cooperative efforts of the Commonwealth and the electric power utilities.

Through this report as a whole the effort has been made to indicate in some detail the direction which the development of such a Giant Power industry should take. Here are the broad outlines:

Location—In Technical Report No. 3—"Natural Resources Available for Power" Dr. Newell has pointed out a number of locations in Western Pennsylvania where Giant Power plants may logically be placed. Those most favorable are on the Allegheny River and particularly in the vicinity of Kittanning. Developments in the art of artificial cooling methods widen the range of choice.

Capacity—In Technical Report No. 1 on "Power Production and Utilization" it is estimated that 2,000,000 kw. will be the required capacity in 1930 of Giant Power base load plants to supply Pennsylvania's power needs when operating on a 60 per cent load factor. Should the improvement in system load factor which it is expected will result from service integrated on a state-wide basis be realized then these stations may be able to operate on an 80 per cent load factor and thus provide a base load source for another ten years.

With the extensive network of high tension lines now in operation in the State, a simple system of trunk transmission lines so placed as to intersect the existing lines would avoid the necessity for competing or paralleling lines, and provide an unlimited source of power for distribution over the lines now installed. With such trunk transmission lines to rely upon for the power supply of the future all

further line construction can be planned on an economic and efficient basis.

Costs[1]—(a) Power Plant

An industry for the production of power on a scale such as proposed by the Giant Power Survey can be installed at less cost than the smaller plants for the manufacture of power now being erected, and for the purpose of this report a "prudent investment" of $75. per kw. has been accepted.

(b) Transmission

The difficulty of arriving at costs where rights-of-way are in question leaves an estimate for a trunk transmission line a matter of a good guess. However, with Government support for such an undertaking, and where railroad rights-of-way and transmission lines are already in existence the problem becomes less formidable. In recent similar investigations this cost has been estimated at 20 cents[2] per kw. mile. This is the figure we have adopted.

(c) Operation

Based on advanced power plant design with an efficiency of 15,000 b. t. u. per kwh. and a by-product development as outlined by Mr. Dickerman, in Technical Report No. 4 on "Pre-Treatment of Bituminous Coals" the operating costs per kwh. will fall below 1 mill. With Government support in financing such a project the fixed charges should be kept well within 10 per cent which would add to operating costs approximately 1½ mills and allowing ½ mill for profit, the cost to a 60 per cent load factor quantity distributor at the power plant bus bars[3] will approximate 3 mills per kwh. While this estimate has been checked and commented upon in such a way as to make us feel that it can and will be realized I am adding to it a ½ mill

[1]See Technical Report No. 6, "A Giant Power Industry" by O. M. Rau, for details of estimates.

[2]See pages 9 and 10 "Superpower Studies, Northeast Section of United States, by Northeast Superpower Committee" May, 1924, issued by U. S. Department of Commerce.

[3]The bus bar is the generally accepted dividing point between the generating station and its transmission system. Bus bars are metal bars into which the generators pour their energy and from which the energy is then sent out over the system.

as insurance against special contingencies and thus to minimize controversy over relatively unimportant details.

(d) Cost to Wholesale Distributor:

Transmission distances being the controlling factor no fixed sum can be established. These wholesale costs are computed by zones and arrived at by adding to the manufacturing cost of the current operating cost of the trunk transmission line, line losses and fixed charges based on these costs for each zone. If the zone districts are established at 50 miles, the cost of power at the primary sub-station secondary bus, assuming an average ten per cent loss, including maintenance costs, and a ten per cent fixed charge:

First Zone	3½ mills	power	cost	plus	2/10 mill	=	3.7 mills
Second Zone ..	"	"	"	"	4/10 mill	=	3.9 mills
Third Zone	"	"	"	"	6/10 mill	=	4.1 mills
Fourth Zone ..	"	"	"	"	8/10 mill	=	4.3 mills
Fifth Zone	"	"	"	"	1 mill	=	4.5 mills
Sixth Zone	"	"	"	"	1 2/10 mill	=	4.7 mills

This means that the whole cost of manufacturing current and transmitting it 300 miles will be less than half a cent per kilowatt hour.

Of course the achievement of any such cost for current manufactured at mine mouth plants and transmitted over 220,000 volt lines will necessarily bring about the slowing down in the building of plants less advantageously situated and especially those on the Atlantic Seaboard. It seems altogether probable that the building of plants away from the mines must ultimately cease. The larger and more efficient plants now built will continue to be operated to take care of peak loads and other special emergencies. With the development of giant mine mouth plants practicing by-product recovery the relative inefficiency of our present generating stations will become more apparent. But because these stations will be operated when a part of a Giant Power system only at the peak of the load and to meet other special emergencies their efficiency becomes relatively unimportant. Therefore under the most active development of stations at the mines we can look forward to a very large percentage of the present installed capacity operating for many years to come. The

mine mouth plants that are built will simply provide in a more economical way for the rapidly increasing demand.

Pennsylvania should be on notice that when mine mouth generated Giant Power has reached the consuming centers in the Eastern part of the State—and more especially the tremendous market represented by the Newark-New York district—and the economy of this routing is once established, there must inevitably follow a fairly rapid duplication of lines of the highest voltage generally speaking

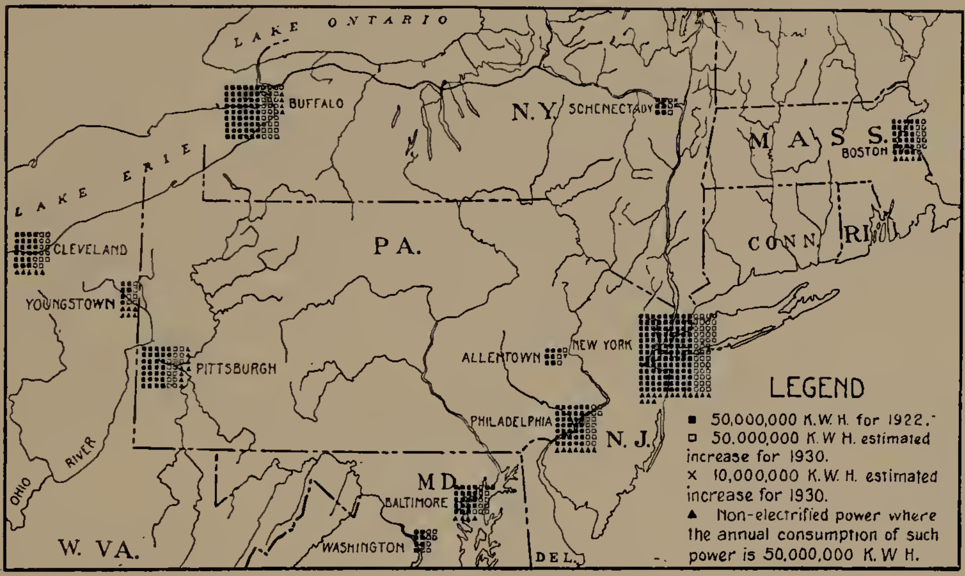

Fig. 7. Relative Size of Power Markets Available to Pennsylvania Power Sources

running East and West over the State. The wise location of such lanes of power constitutes a problem of far reaching significance and one that can not be satisfactorily solved through the progressive but more or less accidental adjustment of the financial interests involved. Giant Power imposes upon the people of this State a group of problems which are novel to the point almost of bearing no relation to those with which we have dealt in the past. They are of a size to tax our capacity for statesmanship.

Note: Transmitted with this general report are three maps mounted on cloth each 8½ x 5 feet—too large for reproduction as a part of a printed report.

Map No. 1 shows all the generating and transmitting facilities throughout

the State as of the date when it was completed—early in 1924. It was prepared at our request by the Public Service Commission through the cooperation of the electric service companies. Its accuracy and completeness was insured through having the facilities of each company drawn in on the base map by the employees of that company.

Map No. 2 shows the chartered territories of each of the electric service companies operating within the State. (Duplicates of Maps Nos. 1 and 2 are on file with the Public Service Commission.)

Map No. 3 shows distribution lines. The area covered—approximately 20 per cent. of the whole area of the state—constitutes the district wherein service is at present obtainable. If this map could be superimposed upon Map No. 2 of chartered territories a good picture would be afforded of the way in which such territories have been actually developed.

Technical Report No. 1

POWER PRODUCTION AND UTILIZATION AS SUPPLIED BY ELECTRIC POWER UTILITIES, MUNICIPALITIES AND ELECTRIC RAILWAYS

By OTTO M. RAU, *Consulting Engineer.*

New possibilities for the furthering of human comfort and well being confront us on all sides and for the realization of all these there is a growing demand for POWER and still MORE POWER.

For comprehensive guidance in providing for this ever-increasing demand for power, an inventory of existing power producing sources is important. Such a survey unquestionably indicates that the future power supply will be distributed and utilized electrically.

The power requirements for the State of Pennsylvania, exclusive of steam roads, reached in round figures the enormous total of 15 billion[1] kwh. for the year 1922. This total was produced by Prime Movers having a capacity of 4¼ million[2] kw. Deducting that re-

[1]Kwh. used for power in Industry (Rittman-Ely)	13,000,000,000
" " " " " Dom. Ser. (Rau)	257,000,000
" " " " " Comm. Ser. (Rau)	660,000,000
" " " " " Mun. Ser. (Rau)	120,000,000
" " " " " St. Ry. Ser. (Rau)	922,000,000
	14,959,000,000

[2]Prime Movers Steel Industry (Rittman-Ely)	1,000,000
" " Misc. Industry (Rittman-Ely)	1,638,000
" " St. Ry. Industry (Rau)	167,000
" " Elec. Pw. Util. Industry (Rau)	1,449,000
	4,254,000

Otto M. Rau is one of the pioneers of the electric lighting industry. He has been connected with the early work of the Daft Electric Light Company and the Edison General Electric Company. He served the latter company as resident engineer during the installation of the electric lighting and railway systems in Milwaukee, Wisconsin, and was promoted to the position of general superintendent in charge of electric light and power for the company. After twenty years of service with the Edison General Electric Company of Milwaukee and the subsidiaries of the North American Company, he served for six years as general manager of the Commonwealth Light & Power Company of Milwaukee, Wisconsin. Mr. Rau left this position in order that he might be available for war service. He was called to the Emergency Fleet Corporation in the capacity of power specialist. Since that time Mr. Rau has devoted his energies, and is using his broad experience and training as a power specialist in the field of consulting engineering.

quired by mining and the steel industry, 50 per cent is supplied by prime movers owned or controlled by the utilities.

Electric power utilities came into being with the commercial application of the Edison lamp. In their early development they were known as "Electric Light Companies." The possibility of generating electric current at a central station and distributing it over wires to the consumers in the vicinity rapidly developed an industry which became recognized as a necessity to progressive communities.

It was soon discovered that not only electric light but also power could be obtained from this service. Rapid progress was made in the development of the possibilities of electric distribution, and the introduction of high voltage transmission brought about a new era for these utilities. The electric lighting companies, originally restricted to relatively small districts, became the power companies of today, spreading out over unlimited territory and sending power wherever there is a profitable market for its utilization, the demand for which has however, always been greater than the supply.

Quite beyond the conception of the layman's mind, these companies have spread their influence until they have become an indispensable factor in the social and industrial life of the country. Pennsylvania, perhaps more than any other state in the Union, has been an attractive field for the development of this industry. The electric lighting companies have been absorbed through purchase or control so that of the many hundred of these local companies, only 155 with prime sources of power generation, remained in 1922, the balance being owned or controlled by 15 holding companies. Ninety-eight per cent of all of the power sold by the electric power utilities in the State of Pennsylvania during 1922 was produced by prime movers controlled by the holding companies, and the balance, 2 per cent, was supplied by the 155 local companies. (Figure 1).

During 1923 great activity was developed in the further consolidation of the local companies, and transmission lines were extended throughout the State. So far-reaching is this development of power distribution, expressed in economic terms, that the very foundation of our social order and well-being may be materially modified. The proper coordination of economic considerations and social effects must be given the most careful study, so that this growing influence, gaining giant-like proportions, may be guided and developed into a useful

and beneficial system, not only for its creators but for the millions of people in this State who can be made more comfortable and more contented under the proper direction of this powerful agency.

Power is now distributed in Pennsylvania at voltages as high as 110,000 and over distances exceeding 100 miles, with little or no con-

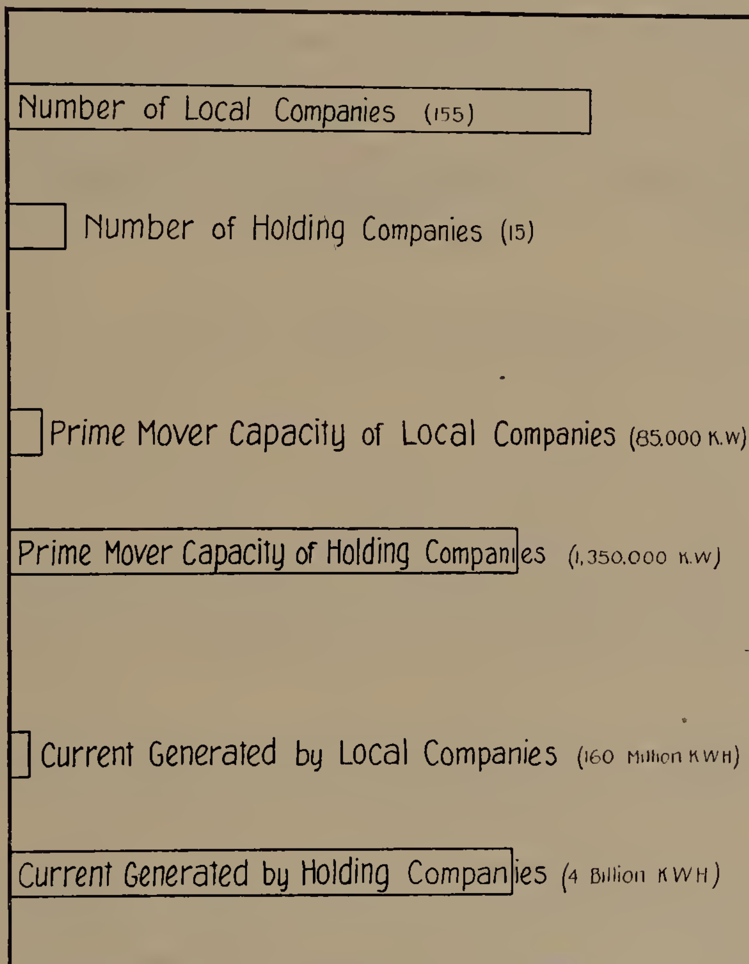

Fig. 1. Holding and Local Companies Contrasted

sideration of statewide requirements or broad economic principles and effects.

To develop a POWER AGE for the State of Pennsylvania the economic factors now largely encouraging these great transmission systems must be discarded. They should be replaced by a conception which will make available in the most economical manner, low cost power in unlimited quantities to the population of the State as a whole.

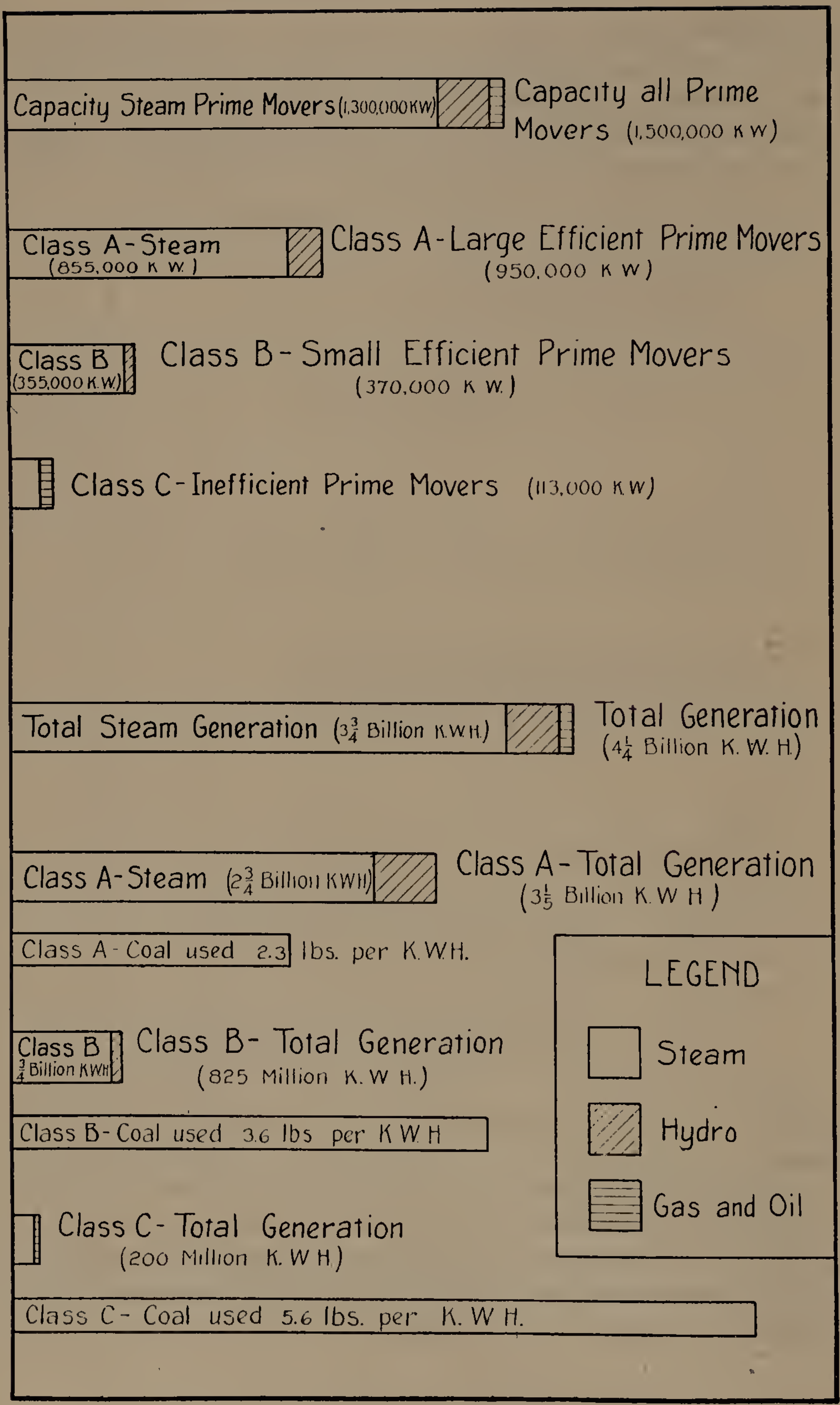

FIG. 2. PRIME MOVER CAPACITIES BY CLASSES

The total capacity of prime power sources of the power utilities within the State is 1,448,875 kw. of which 115,994 kw. are operated by water power, 1,313,592 kw. are operated by steam and 10,891 kw. by gas or oil engines. The total power generated from these prime power sources during 1922 was 4,238,260,351 kwh. Of this total, 483,232,506 kwh. were produced by hydro-electric generation, 3,725,591,998 kwh. by steam generation, and 26,335,837 kwh. by gas and oil engines, or 11 per cent hydro-electric, 88 per cent steam and less than one per cent gas and oil. (Figure 2).

The total amount of exhaustible natural resources utilized in the production of the 4,238,260,351 kwh. was 4,578,902 short tons of coal, (Figure 3) 440,000,000 (estimated) cu. ft. of natural gas, and

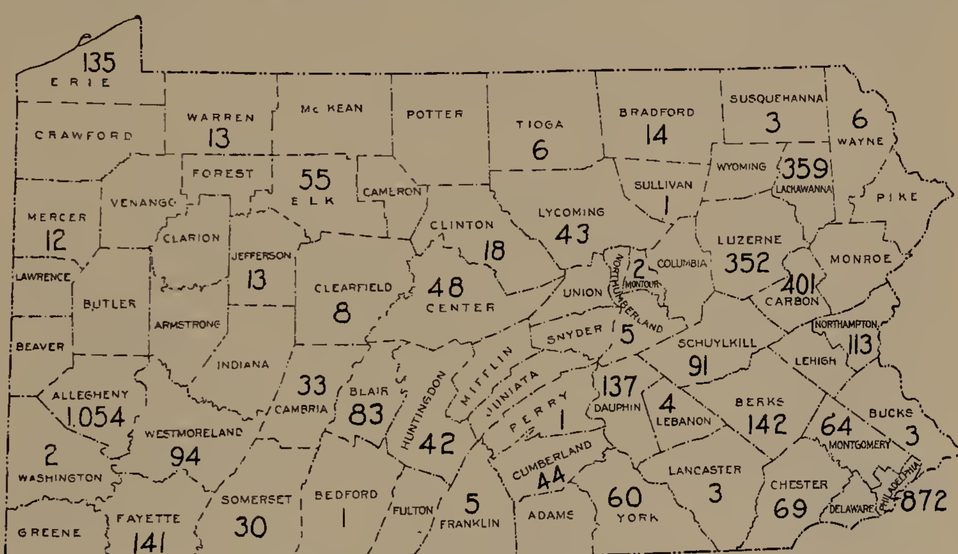

FIG. 3. COAL USED BY COUNTIES
(Figures Indicate Tonnage in Thousands)

350,000 (estimated) gallons of oil. Seventy-six per cent of the power generated by prime movers required an average coal consumption of 2.3 lb. per kwh., 18 per cent averaged 3.6 lb., and 4 per cent, 5.6 lb.

The water used by the hydro-electric plants is in quantity, approximately 60,000 cu. ft. per second, which is equivalent to 3 times that of the American allowance at Niagara Falls. Due to the varying head, which is low in most instances, the power actually developed is but 33 per cent of that obtained from Niagara Falls, and with the exception of the hydro-electric plant at Holtwood and the one at York Haven, this power is not a source of "economic power production." But due to the social importance of the utilization of the water powers

within the State so as to conserve the exhaustible natural resources for power production, it is an important prime source of power, becoming more so as the other natural resources for power production become exhausted.

The prime sources of power generated by steam can be considered in three classes: "A" Large, highly efficient generating plants, "B" Small, efficient generating plants, and "C" Inefficient plants of all types.

The Class "A" plants have a total installed capacity of 885,230 kw. and generated during 1922 a total of 2,756,375,722 kwh. consuming 2,899,784 short tons of coal, which is an average of 2.3 lb. per kwh. (Figure 4).

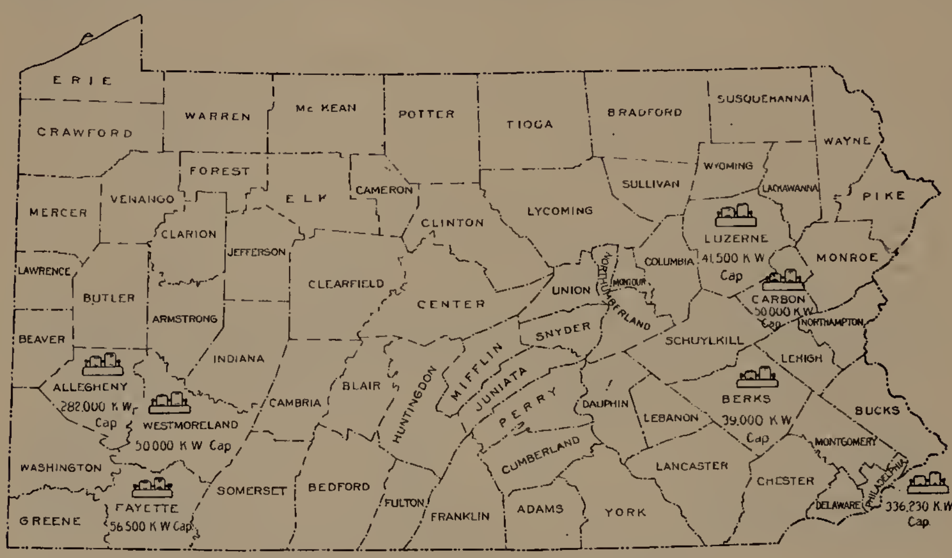

FIG. 4. CLASS A PRIME MOVERS

The Class "B" plants have a total installed capacity of 355,270 kw. and generated during 1922 a total of 787,396,601 kwh. consuming 1,231,754 short tons of coal, which is an average of 3.6 lb. per kwh. (Figure 5).

The Class "C" plants have a total installed capacity of 103,092 kw. and generated during 1922 a total of 181,971,675 kwh. consuming 447,364 short tons of coal, which is an average of 5.6 lb. per kwh. (Figure 6).

The Class "A" plants generated 75 per cent of the total, Class "B" plants generated 20 per cent, and Class "C" plants generated 5 per cent.

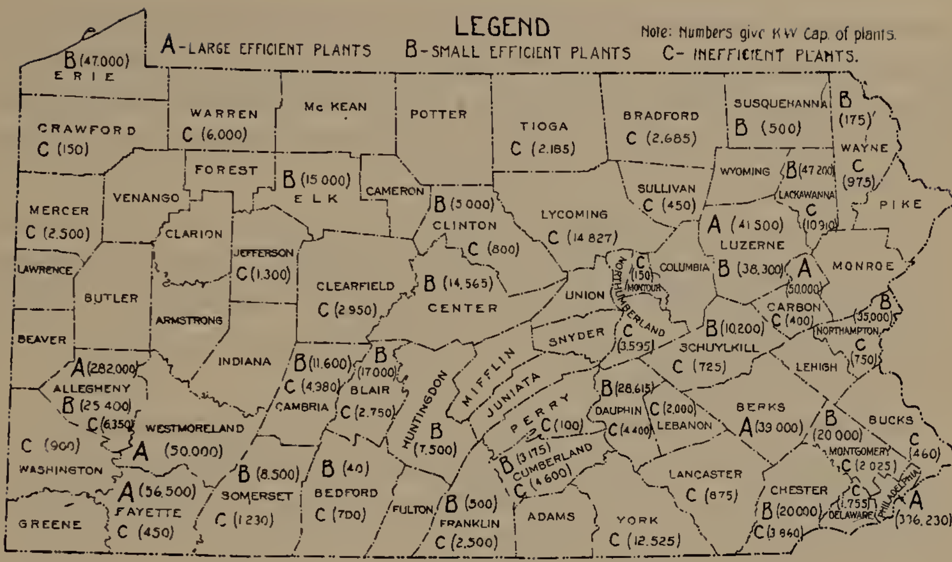

FIG. 5. PRIME MOVERS—STEAM PLANTS

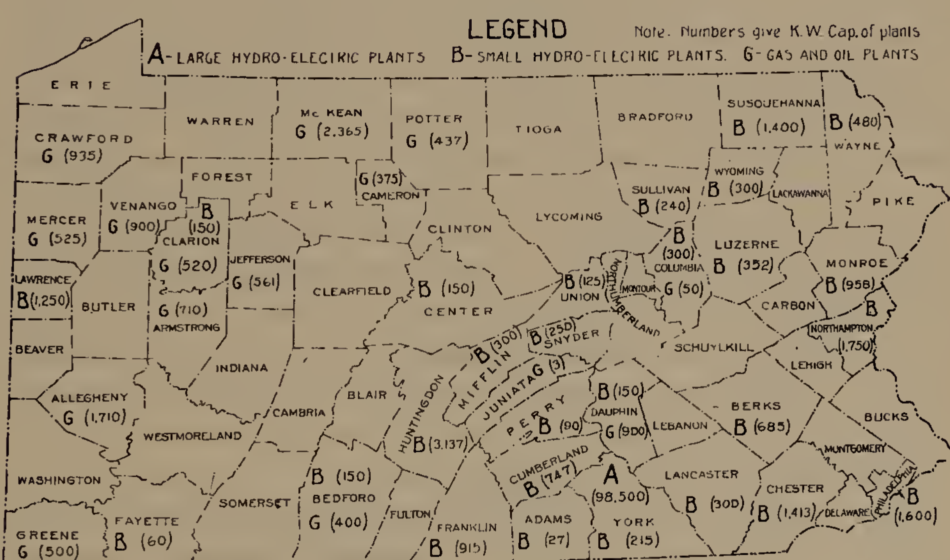

FIG. 6. PRIME MOVERS EXCEPTING STEAM

The generation of electric power by the power utilities is confined to 60 out of the 67 counties in the State of Pennsylvania. Eighty per cent is produced in the counties of Allegheny, Berks, Carbon, Fayette, Lackawanna, Luzerne, Philadelphia and York. The balance, or 20 per cent, is produced in 52 counties.

The electric utilities not producing prime power obtained for re-

distribution a total of 203,769,215 kwh. from the utilities having prime sources of power. Of this amount 4,776,759 kwh. were again delivered by the utilities purchasing power to other utilities for distribution to consumers. Power utilities producing prime power purchased or exchanged a total of 334,649,046 kwh.

Of the total prime power produced within the State, 284,547,200 kwh. (approximately 7 per cent) were delivered beyond the borders of the State, and of the total power used in the State 342,047,831 kwh. (approximately 8 per cent) were obtained from prime power sources beyond the State borders.

The Load Factor was given careful study. Its relation to the efficient production of power and the possibilities of favorably modifying the existing load factors are so important that the details cannot be taken up in this report, but will be covered in the appendix by a chapter dealing with this subject.

The Load Factor varies from as low as 20 per cent up to 50 per cent for the prime power producing sources. From over-all figures the Load Factor within the State for the year 1922 was 34 per cent.

The production of power from prime sources located without regard to the most economical production or use, results in a wasteful demand on the transportation facilities of the State. It is estimated that for the power produced from coal for all uses exclusive of steam railroads within the State, there was required sufficient power to handle a total of 3 billion ton miles, to transport the fuel to the point of consumption, which is 33 per cent of the total ton miles of freight handled by the railroads within the State. In many instances the power available from the coal hauled to the prime power sources is transmitted for miles back towards the location in which the power, in the form of coal, originated.

These studies of the electric power utilities indicate that the economical production of power, developed to provide a statewide distribution, will conserve the natural resources of the State, eliminate wasteful use of the transportation facilities, and provide power which will bring industrial activity and social convenience to every inhabitant of the Commonwealth.

Electric service is estimated to be available to 6,540,441 persons, 75 per cent of the population of the entire State. Of the population where service is available, 43 per cent, or 2,814,197 persons can be found in the counties of Philadelphia and Allegheny. The balance,

or 3,740,430 persons, are distributed over the remaining 65 counties of the State, having a total population of 5,740,430. Only 65 per cent of this population has electric service available. Of the 1212 incorporated places in the State, 785 have electric service. (Figure 7).

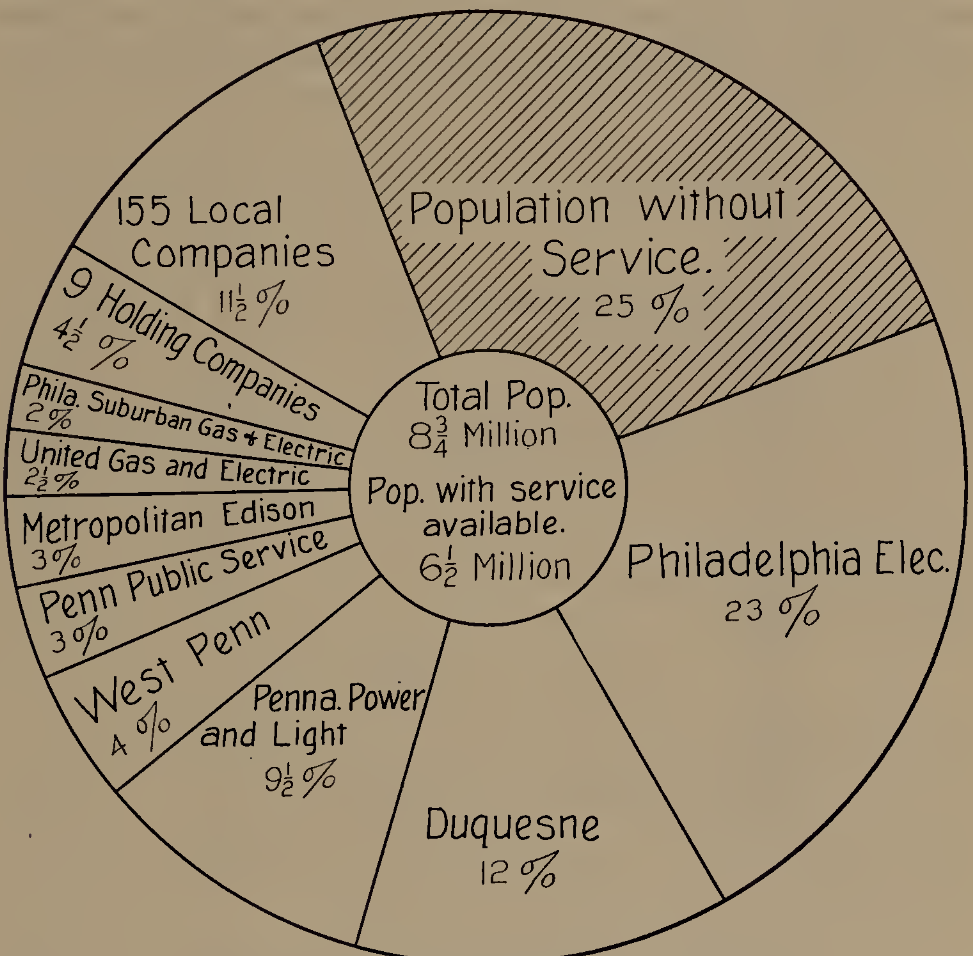

Fig. 7. Populations Served by Companies

The area within the State where electric service is available (assuming a reasonable distance paralleling the distribution system) is estimated as 8966 sq. mi. or 20 per cent of the area of the State. Allowing 20,703 sq. mi. for waste lands, forests, etc., where no service could be reasonably demanded, there is left an area of 15,163 sq. mi., not as yet electrified, in which service should be available. Deducting the counties of Philadelphia and Allegheny, the entire area of which is practically covered with distributing lines, there is approxi-

mately 78 per cent of the remaining land area of the State unsupplied with electric service.

The use of power generated by the electric power utilities is distributed over all but two counties in the State. Of the 2,835,586,048 kwh. delivered to consumers exclusive of steam railways and other utilities, 1,767,740,326 kwh. are used for industrial power by 37,437

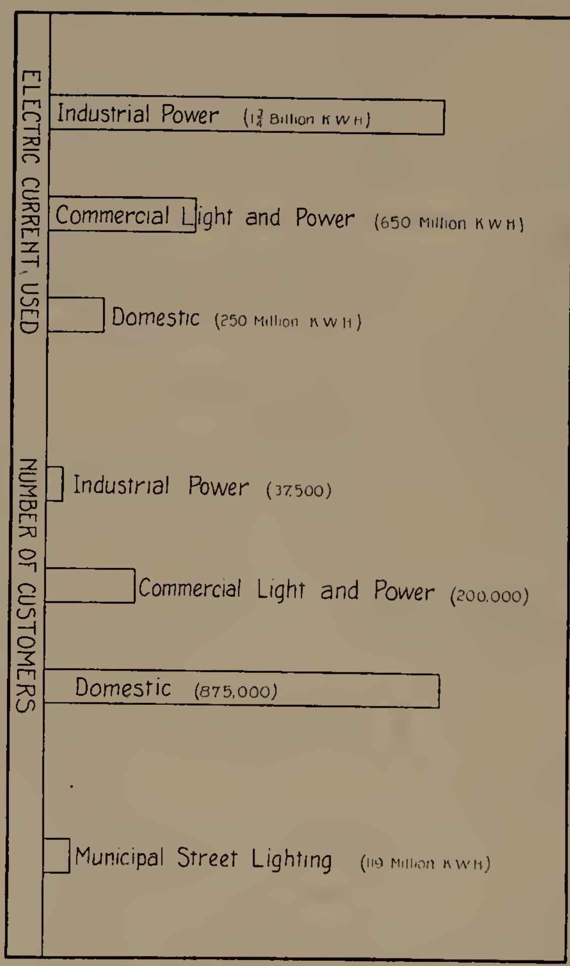

FIG. 8. CUSTOMERS AND USE CONTRASTED

consumers; 659,946,757 kwh. for commercial power and light by 197,888 consumers; 256,719,510 kwh. for domestic or residence service by 874,456 consumers, and 119,179,454 kwh. for municipal lighting. This is an average per consumer of approximately 50,000 kwh. for power; 3,300 kwh. for commercial lighting and power and 300 kwh. for domestic service. (Figure 8).

The electric power companies are supplying approximately 90 per cent of the power used within the State, exclusive of that required by steam railroads, electric railways, and the steel and mining industries. The increasing ratio of purchased power to that supplied from private plants indicates that except in instances where an industry requires steam for other purposes than power, or where favorable conditions exist for the economical production of power in a private plant, the electric power utilities will supply the service. With efficiency in production, in quantities to meet the demand, all but a small per cent of the power used within the State can be supplied from central stations.

There are 55 municipal plants operating in the State, located in 26 counties: 27 have prime power generating plants from which they obtain all or part of the power required to supply the district in which they operate; 19 plants purchase all the power required from electric power utilities; and two plants sell power to an electric power utility. These plants have a prime mover capacity of approximately 17,545 kw. generating 12,469,981 kwh. They purchase 6,522,616 kwh. They deliver 2,418,535 kwh. for power to 659 customers, 2,690,242 kwh. for commercial light and power to 2,252 customers, 1,822,940 kwh. for domestic service to 13,667 customers and 1,994,547 kwh. are used for street lighting.

The electric railways have recognized the advantage of purchasing power from the electric power companies, and in many instances have abandoned their generating plants, or use them as stand-by capacity or for peak load service. On the smaller roads the demand for power fluctuates so that efficient operation is difficult and on large systems the load factor is such that a very low rate for purchased power is obtainable. It can therefore be anticipated that the prime mover capacity now operated by electric railways will not materially increase, and that ultimately the greater part of the power required to operate these roads will be obtained from the electric power companies.

There are 122 electric street railway companies operating in 55 counties of the State, occupying 1,570 miles of city streets, 891 miles of highways, and 1,404 miles of private right-of-way. Nineteen companies have prime sources of power with a total capacity of 166,507 kw. all of which are in steam power plants with the exception of 4,250 kw. which are in gas or oil engine plants. The total power

required was 921,062,435 kwh. of which 616,866,077 kwh. (67 per cent) were purchased and the balance, 304,176,358 kwh. generated by their own plants.

The total coal required for steam generation was 519,698 short tons (3.6 lb. per kwh.)

The Steam railroad industry is one of the largest power consuming industries in the State. There are 94 operating companies occupying 10,286 miles of right-of-way. To arrive at the power required to operate that part of these systems, within the State, the average power required per unit of service, such as car mile for passenger service, ton mile for freight service, and locomotive mile for switching service, was arrived at, from which the total power required was calculated.

The passenger service required a total of 250,442,147 car miles estimated at 3.2 kwh. per car mile; 803,919,291 kwh. The freight service required 88,106,970,809 ton miles at 25 kwh. for 1000 ton miles used; 2,227,678,250 kwh. For switching service the motive power was operated a total of 45,323,299 miles—estimated to use 12.5 kwh. per locomotive mile. This required 566,541,237 kwh. or a total for all service of approximately 3½ million kwh.

The total coal used was 11,241,203 short tons, or in excess of 6½ lb. per kwh. on the basis of the above assumption.

Efficient steam power generating stations could produce this power at not to exceed 1½ lb. per kwh. Allowing ½ lb. for transmission and other losses, the power could be delivered to the locomotives at not to exceed 2 lb. per kwh. which would produce from the same amount of coal now used by the steam roads fully three times the amount of power required to operate them.

The economy of electric operation of steam roads is sufficient to anticipate that with an abundant supply of low cost power available, progress in the electrification of these roads will be materially advanced, and that the economies possible not only in the conservation of natural resources, but also in the improvement of our transportation facilities particularly at terminals will alone warrant the efforts of the Giant Power Survey towards making available the power necessary for their operation.

Summarizing the total power production and utilization within the State, we get the following astounding figures:

PRODUCTION

Prime Mover Generation (Steam)	*Kwh.*	*Coal Used (Short tons)*
Electric Power Utilities	3,726,000,000	4,580,000
Electric Railways	304,000,000	520,000
Industrial Power	9,800,000,000	22,740,000
Steam Railways	3,550,000,000	11,240,000
	17,380,000,000	39,080,000
Prime Mover generation other than steam	520,000,000	
Total Generation ..	17,900,000,000	

UTILIZATION

	Kwh.
Steam Railways	3,500,000,000
Iron and Steel Industry	6,763,000,000
Mining	2,000,000,000
Industrial Power	3,700,000,000
Commercial Light and Power	660,000,000
Domestic Service	257,000,000
Municipal Service	120,000,000
Electric Railways	900,000,000
	17,900,000,000

These figures assume proportions, taking into consideration the annual increase during the past ten years, that become alarming and most vividly picture the probability of the exhaustion of our coal supply, the conservation of which is so important to the Commonwealth of Pennsylvania.

With a Giant Power industry established, economics become possible which will indefinitely postpone the day of accounting, and with similar programs for adjoining states, will retain the mainstay of Pennsylvania's industries, her natural coal resources, for the people of this State for centuries to come. The production and wide-spread distribution of electric power from a Giant Power industry should at least maintain the present coal consumption as a

maximum for many years by displacing the wasteful methods of power production. Assuming such an industry as launched in 1925, the economies may be estimated as follows:

GIANT POWER LOAD INCLUDING PRESENT EFFICIENT POWER SOURCES

	Kwh.	*Lbs.*	*Coal Used*
1925	18,000,000,000	@ 4½ per kwh.	40,000,000
1930	27,000,000,000	@ 3 per kwh.	40,000,000
1940	54,000,000,000	@ 1½ per kwh.	40,000,000
1950	108,000,000,000	@ (?) per kwh.	(?)

Such a program will allow for the amortization of all wasteful existing power sources without financial loss, will provide a definite program for the expansion of industrial power requirements, and will allow new developments, and enterprises to be undertaken in Pennsylvania with the assurance of an unlimited supply of power at a minimum cost.

Technical Report No. 2

INDUSTRIAL POWER

WALTER F. RITTMAN AND SUMNER B. ELY,
Profs. of Commercial Engineering, Carnegie Institute of Technology.

PENNSYLVANIA USES MUCH POWER

Pennsylvania uses as much power in industry as any two states in the United States. In the year 1922 this energy amounted to approximately thirteen billion kilowatt hours, which does not include the power supplied by electric power companies as commercial light and power, domestic and municipal lighting nor power used by electric and steam railways. This means that the man power of the Commonwealth was augmented by water and fuel power equivalent to 2,000,000 horses working continuously day and night throughout the year. Five counties alone use more power than the entire State of Ohio. In 1900 approximately 2-½ horsepower was available per worker while today 4 horsepower is the average for each worker in

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WALTER F. RITTMAN, PH.D. is a graduate civil, mechanical and chemical engineer, who has had professional experience in all three fields. In addition to his general consulting practice, he was for some years consulting engineer to the United States Bureau of Mines. At the present time Dr. Rittman is Professor and Head of Department of Commercial Engineering at the Carnegie Institute of Technology, Pittsburgh, Penna. He is a member of the Am. Soc. of Mech. Eng., Am. Inst. of Chem. Eng., Am. Inst. of Mining & Met. Eng., Society Industrial Engineers, Franklin Institute, and other engineering and scientific societies. He has published extensively in the fields of oil, gas and fuel, and many of these writings have been translated into the more important foreign languages.

SUMNER BOYER ELY is a graduate of M. I. T. 1892. He was sent to Egypt by the Pressed Steel Car Company of Pittsburgh, Penna., to erect the first shipment of steel cars sent abroad.

As Chief Engineer of the American Sheet Steel Company he studied continuous sheet rolling in Germany. When this Company was merged into the American Sheet & Tin Plate Company he became its Chief Engineer.

For several years he was Secretary of the Board of Engineers of the U. S. Steel Corporation.

the Commonwealth. In the light of these facts, the commanding position of Pennsylvania is probably the result of using fuel power to make each worker more effective as a producer of material wealth. Because of the Commonwealth's fuel reserves there is every reason why the Commonwealth should continue this commanding position in Industry.

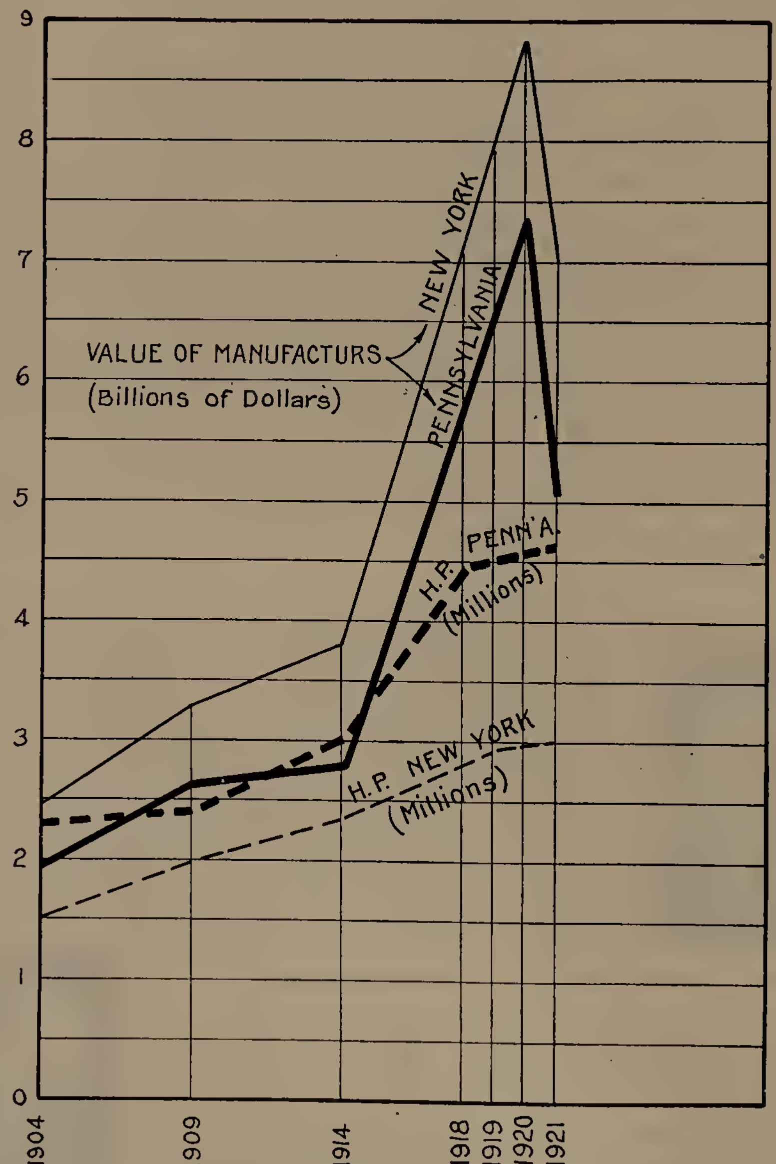


FIG. 1. VALUE OF MANUFACTURES AND INSTALLED H. P., PENNSYLVANIA AND NEW YORK

A Leading Industrial State

The value of Pennsylvania's manufactured products is second only to the value of those of New York. This commanding position is far from secure; it may even be in serious jeopardy. This danger results from the fact that the worker formerly had to live and work

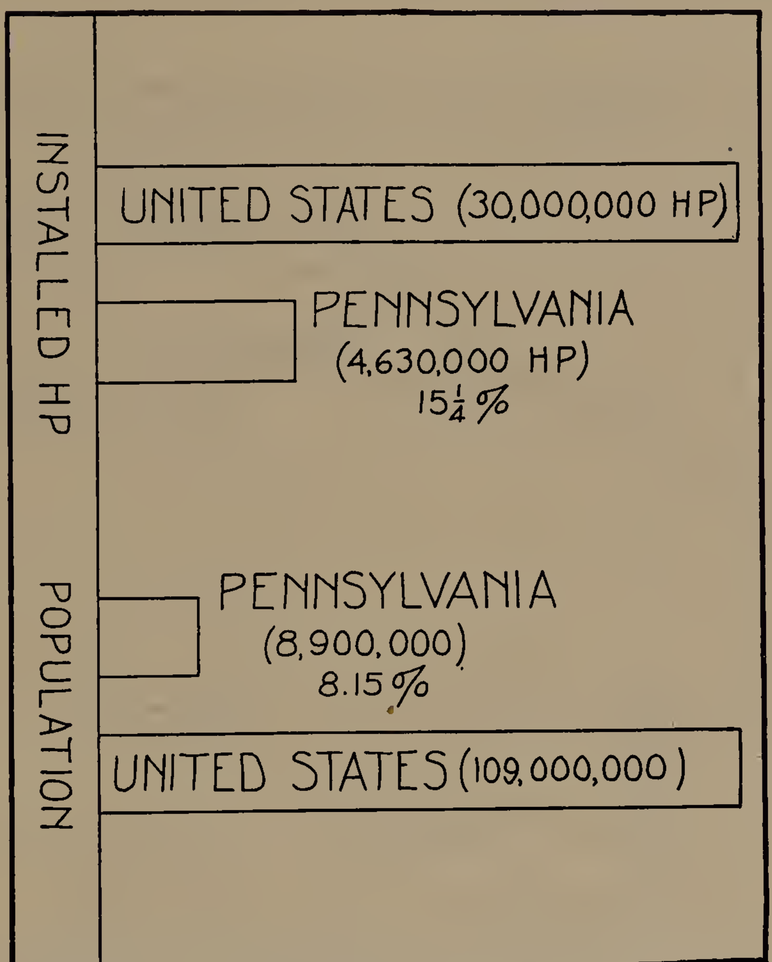


Fig. 2. Power and Population

at the source of fuel and water power. His sphere of industrial freedom was largely determined by the length of the factory belt. Today this same power is shipped over wires to the worker, regardless of the source of Power. This changed order requires an inventory of present conditions and possibilities, which very probably will re-

sult in readjustment in any program for future development and expansion. If Pennsylvania meets the situation squarely and promptly she can continue to be the leading industrial State in the United States. In addition, she can lead in the movement to eliminate the slums and congested city districts which have resulted from the necessity of congregating workers at the source of fuel or water power. Furthermore, she can provide power in abundance to those who are without such power today.

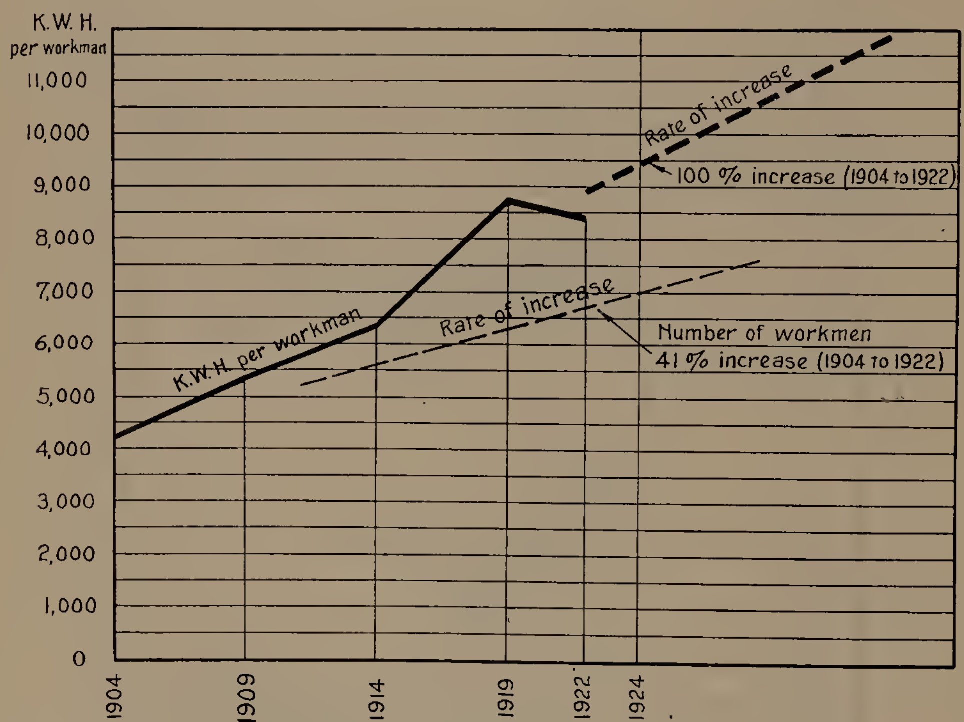


FIG. 3. CONSUMED POWER PER WORKMAN, MINING AND MANUFACTURING INDUSTRIES

STATE CAN MEET FUTURE DEMANDS FOR POWER

Pennsylvania stands foremost among the states in her ability to meet an ever increasing demand for power. The greater the volume and the lower the cost of this power the more secure will be the industrial supremacy of the Commonwealth. It is commonly recognized that the productivity of the worker and the rate of wage paid to each worker is related to the amount of power at the command of that worker. It is further recognized that the happiness and population of a community are dependent upon the opportunity to earn good

wages. The extent to which power per worker has progressively increased in Pennsylvania can be observed from Figure 3, which shows that in 1904 there were 4200 kilowatt hours per worker, whereas in 1922 this has increased to 8500 kilowatt hours used per worker; an increase of over one hundred per cent. It is largely for this reason

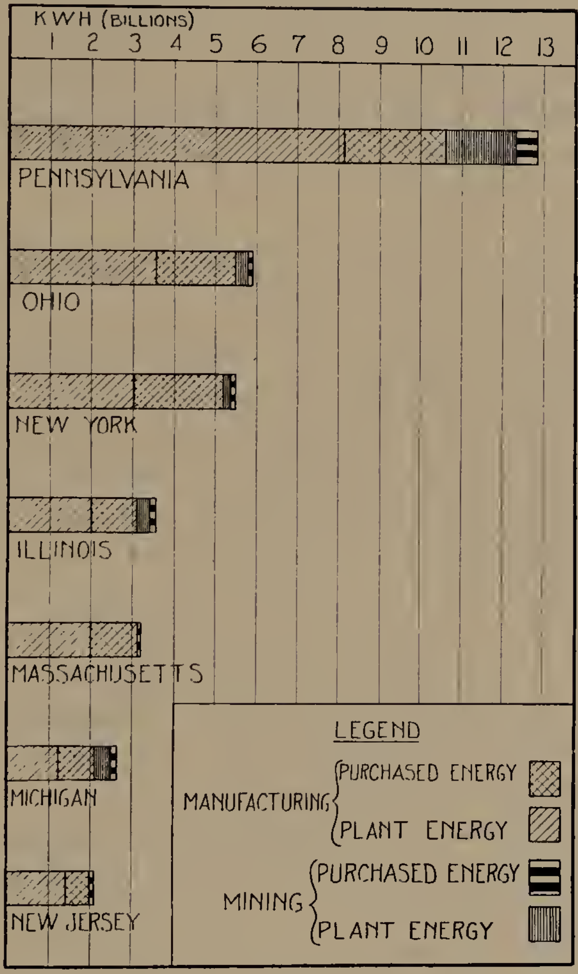


Fig. 4. Energy Consumed in Industry (1922) in Manufacturing and Mining
The Seven Leading Industrial States

that today we all enjoy in our everyday life what were the luxuries of even twenty years ago.

Wealth in the Commonwealth of Pennsylvania has always been measured by advance in industry. During the year 1922 more than 75% of the dollar value of wealth from all sources produced in the Commonwealth was from manufacturing. About 14% of the wealth

of the Commonwealth created in 1922 was from the mines and about 6% from agriculture.

A study of the above brings out the necessity of facing the future with respect to a program covering conservation, development and distribution of power, be it for manufacturing, mining or agriculture. The resources of Pennsylvania are not unlimited. Any progressive development must carry a conservation policy for the good of all. The present generation owes it to posterity to develop a program which will conserve the resources of the State and at the same time retain for the State its position in the Union. There is a responsibility which must not be ignored.

The Importance of Power and by Whom Produced

The importance of power in the Commonwealth is shown in a striking manner by Fig. 4, which shows the total kwh. for 1922, both generated and purchased for industry and mining. This indicates the predominating position of Pennsylvania in the group of leading industrial states. The relative positions of the three producing industries in the State are shown in Fig. 5. Manufacturing industries are so essential to progress in the State that conditions must be made favorable for their development.

The production of power naturally divides itself into two classes:

1. Power produced by the industries themselves by the direct application through mechanical means to the manufacturing equipment or produced by electric generation in local plants and used within the manufacturing establishment.

2. Power produced by the electric power utilities from electric generating plants and delivered to users scattered over great areas surrounding the generating plant or transmitted to distant points and there delivered to the users.

Industrial power in the present report is that power used for manufacturing and mining purposes whatever its source. This includes all the power generated by the industries themselves and also all the power purchased by the industries. A manufacturing plant may own boilers and engines and generate two-thirds of the power it uses, but purchase the other third from some central station or utility company. At the present time, the power generated by the industrial plants themselves amounts to approximately seventy-five percent of the total used. In the early development of the Common-

wealth the industrial plants generated all their own steam power. The recent developments in industry have been for the industries to purchase more and more of their power in the form of electric energy from large central power generating plants. Except under special conditions, the small isolated power plant appears to be doomed. The trend has been to substitute electric power for me-

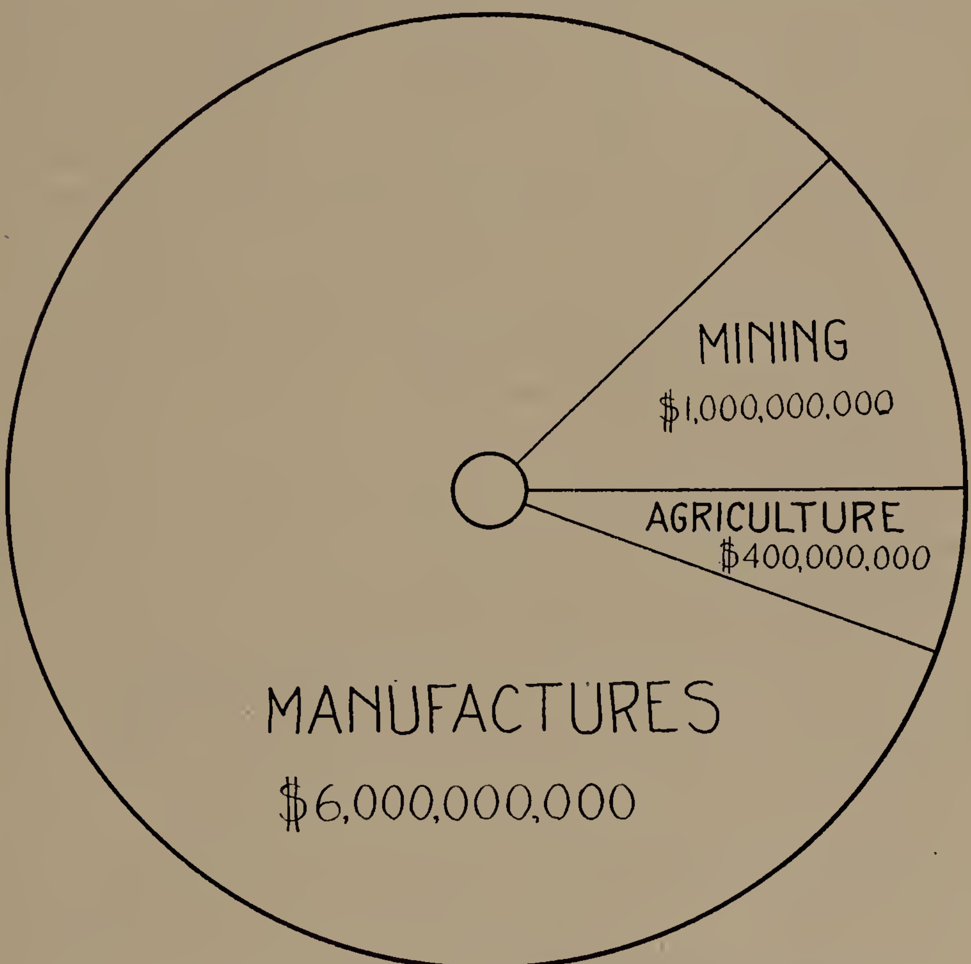


FIG. 5. VALUES PRODUCED IN THE THREE PRODUCING INDUSTRIES OF PENNSYLVANIA, 1922

chanical power. This change is the result of the more efficient power generating plants and the ability to transmit that power over long distances. More efficient prime movers are now well beyond the experimental stage and are coming more and more into use. Witness the large electric central stations. The economy in generating power in such plants is due to the fact that larger plants require less labor

per unit of power output than do small plants and the apparatus in large sizes will, generally speaking, show economy in fuel consumption.

VOLUME OF INDUSTRIAL POWER IN PENNSYLVANIA

In studying power developments in any community a number of factors, all of which are important must be considered. The installed horsepower is a form of barometer but by no means complete. The service factor is the number of hours in a year that the installed horsepower is in use. It has always been a characteristic of Pennsylvania industries to operate over a considerably greater number of hours per year than the industries of other states. The western portion of the State is apt to think in terms of twenty-four hours per day of operation. This would mean that a given number of installed horsepower there, would give three times as much power as would an equal number of installed horsepower which operated only for eight hours which much more nearly represents average use throughout the State.

It also is very generally recognized that no two plants are operated with the same order of efficiency. This means that figures based on installed horsepower permit of interpretation and latitude. Another important consideration in the development of power requirements and consumption, is the form in which the power is used. For instance, in one plant much of the power may be used as steam for other than power purposes; in another it may be used entirely as mechanical power efficiently and closely communicated, whereas in a third the power may have been shipped as electric energy a hundred miles and have experienced not only the transmission losses, but transformer, motor and other conversion losses. The energy taken from installed horsepower involves the element of time of operation and is expressed in terms of kilowatt hours, *i. e.*, the number of kilowatts used over an hour's duration.

Fig. 6 is presented to show the change in volume of installed horsepower in the seven states which lead in use of power in manufacturing and mining operations. If the present rate of power increase continues the Commonwealth of Pennsylvania by 1950 will require approximately double the installed horsepower which exists today. It is questionable whether this increase can be carried out under the present practice of operating power plants within a manu-

facturing plant. There is the limitation of water supply and of coal transportation. The solution would seem to be the purchase of industrial power from large power producing plants strategically located with respect to fuel and water. This seems to be borne out by the fact that the trend today is toward the purchase of central station power rather than the continued development of individual plant power. A long vision would seem to demand a present program definitely anticipated and intelligently designed. The benefits that may be derived from a wise policy will otherwise be lost.

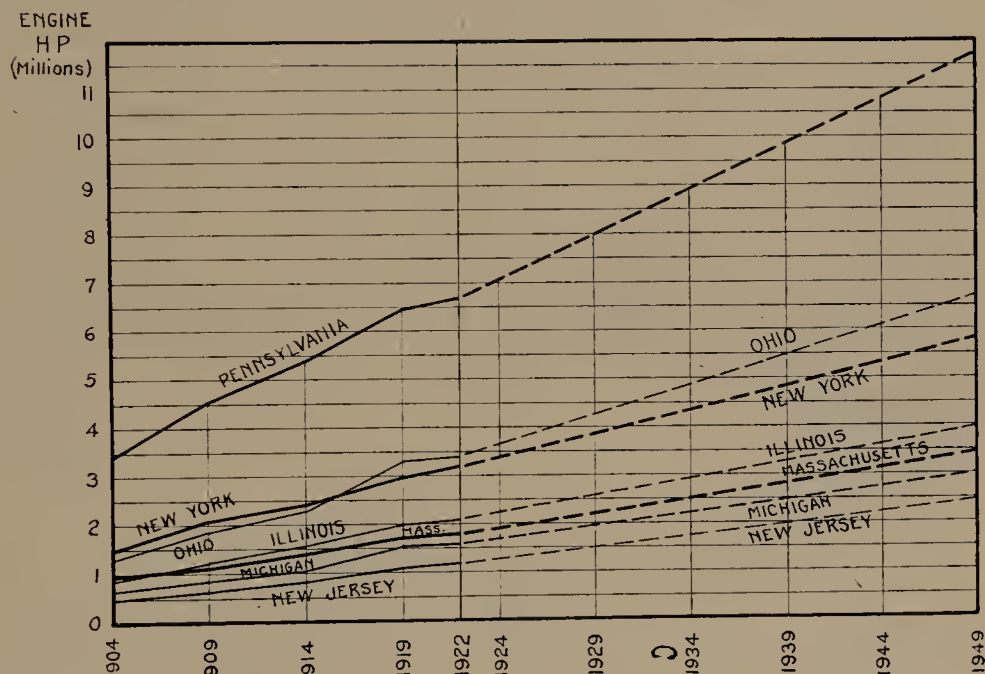


Fig. 6. Horsepower Installed in Manufacturing and Mining Industries in the Seven Leading Industrial States

Fig. 6 shows the total installed primary horsepower in the State in the year 1922 to be 6,650,000 horsepower. Of this, 1,460,000 horsepower was furnished by motors installed in the plants but operated by purchased electric power generated in large central station plants. While Pennsylvania has twice the volume of installed power in industry of any other state, the equipment operated by purchased (or transmitted) energy in the leading states, is approximately the same. The chart shows that Pennsylvania must keep abreast of tendencies in other states to retain its position in industry. The State has increased its power installations in recent years be-

cause it has been possible to operate equipment by purchased or transmitted energy. The possibilities are clearly shown in the case of Ohio as indicated on the chart. The rapid rise in the power of that State is due to transmitted power.

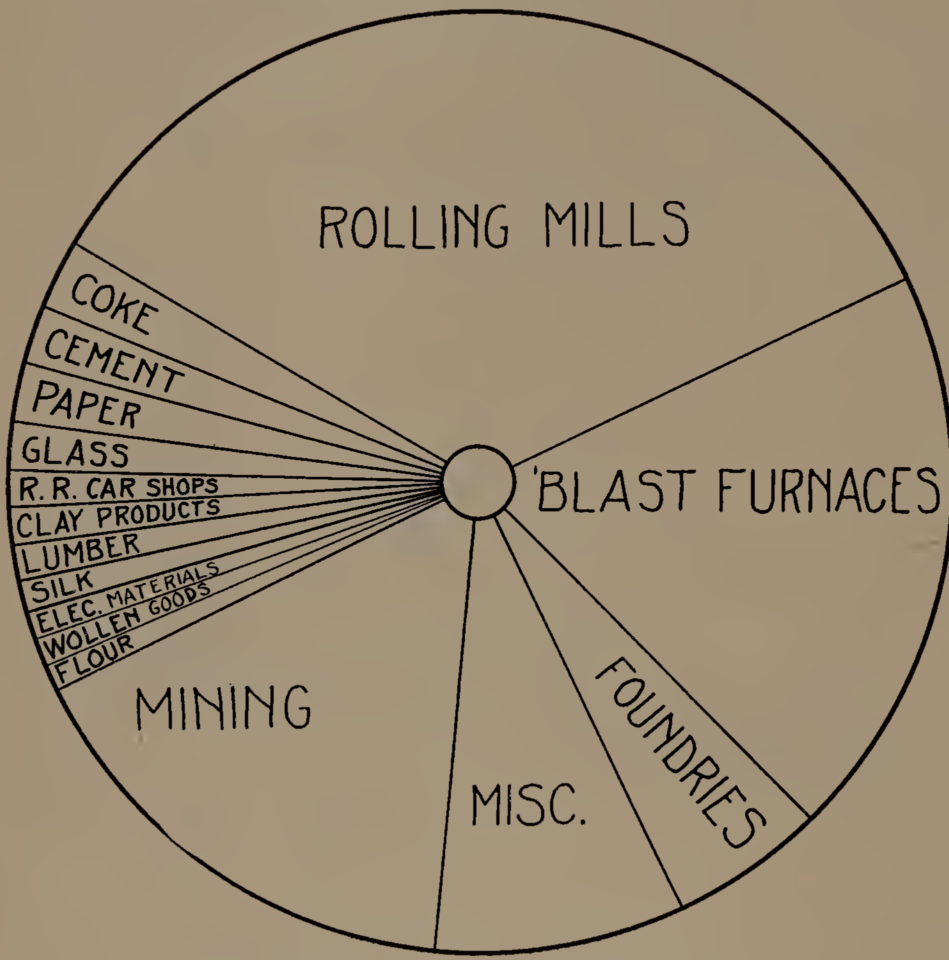


FIG. 7. CONSUMED ENERGY, 1922
Manufacturing and Mining (Equivalent kwh.)

IRON AND STEEL A MAJOR INDUSTRY

Just as the production of the iron and steel industry constitutes the major portion of the value of all industrial products of Pennsylvania so does this industry represent the major power consumption of the Commonwealth. Fig. 7 shows the relative proportions of installed power requirements of the manufacturing and mining industries of Pennsylvania for the year 1922. While the iron and steel industry

uses nearly fifty-four percent of the energy consumed in the State the installed power required to provide it is only thirty-two percent of State's total. This difference is due to the fact that the iron and steel industry is largely a twenty-four hours a day and a seven day a week industry, whereas most of the other industries operate forty-eight to fifty-four hours per week only.

The data available covering the electric utilities is complete, up-to-date and dependable. Largely through the standardization introduced by the Public Service Commission into their accounting and reporting methods the statistics from the several companies are on a comparable basis. Unfortunately almost the opposite is true as to the data about the unregulated individual plants. The U. S. Census of Manufacturers—taken every five years—has been the chief dependance of the students in this field. But in order to arrive at those figures basic to the Giant Power inquiry, and to have them reasonably dependable special inquiries by geographical districts and by specific industries were conducted. It is impossible to claim for these that degree of engineering precision which would be desirable. Any possible factor of error, however, would not materially affect conclusions based on the data.

PENNSYLVANIA INDUSTRIES ARE DIVERSIFIED

Because of the importance of the iron and steel industry to Pennsylvania it is often erroneously believed that the State is dependent primarily on this one industry. It has long been recognized that diversified industry just like diversified farming is essential to the stable prosperity of a community. It is not generally recognized to what extent Pennsylvania has developed in fields other than iron and steel. The iron and steel industry continues to expand and will probably constitute the backbone of Pennsylvania industry for some time. While this industry is doubtless the foundation of the industrial structure of the State the progress of the State during the twenty years just past has been largely due to other industries, most of which produce the necessities of life and therefore serve as the basis for a conservative development. With Giant Power a reality it will be possible for all industries to expand within the State.

GEOGRAPHIC DISTRIBUTION OF PENNSYLVANIA INDUSTRIAL POWER AND POPULATION

In the early stages of American industry people settled near water and coal resources which fixed the location for all industry. In no State was this more true than in Pennsylvania. Today we find congested cities with accompanying high rents and unsanitary conditions in many districts. In the greater part of the State's area population is scattered and relatively little manufacturing is done. As a result of this distribution eighteen counties of the sixty-seven contain ap-

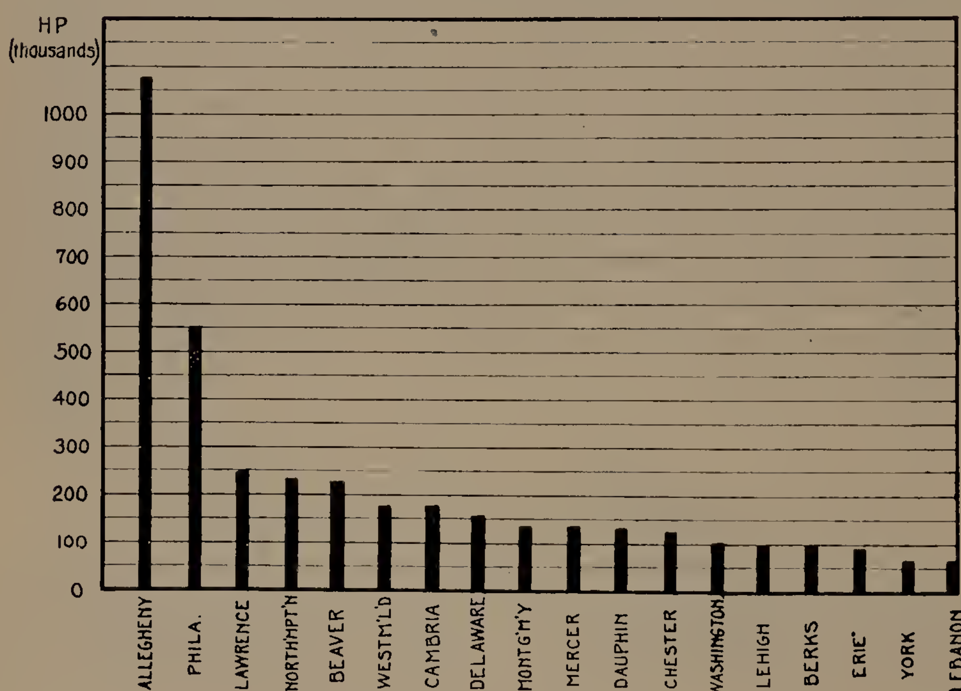


FIG. 8. INDUSTRIAL INSTALLED H. P. BY COUNTIES IN PENNSYLVANIA

proximately eighty-three percent of the total installed power, exclusive of mining, while the other forty-nine counties have only seventeen percent of the total. Fig. 8 shows this graphically. When consumed energy is considered the disparity is even greater. Fig. 9 shows the consumed energy in industry, exclusive of mining, in the various counties in Pennsylvania during the year 1922. The western part of the State consumes much greater volumes of power than the eastern section.

In fact when the area and the population of the State are con-

sidered it is evident that power is not distributed to the extent warranted by modern conditions. A study of the concentration of population in the State shows clearly how industry followed power and built the cities of Pennsylvania. It is believed that the development of Giant Power which permits of shipping power wherever it is needed will again influence the migration of population and cause other communities to develop into important industrial cities planned to meet present and future needs. In other words, industry in adjusting itself to the electrical age may easily be located in large areas not now

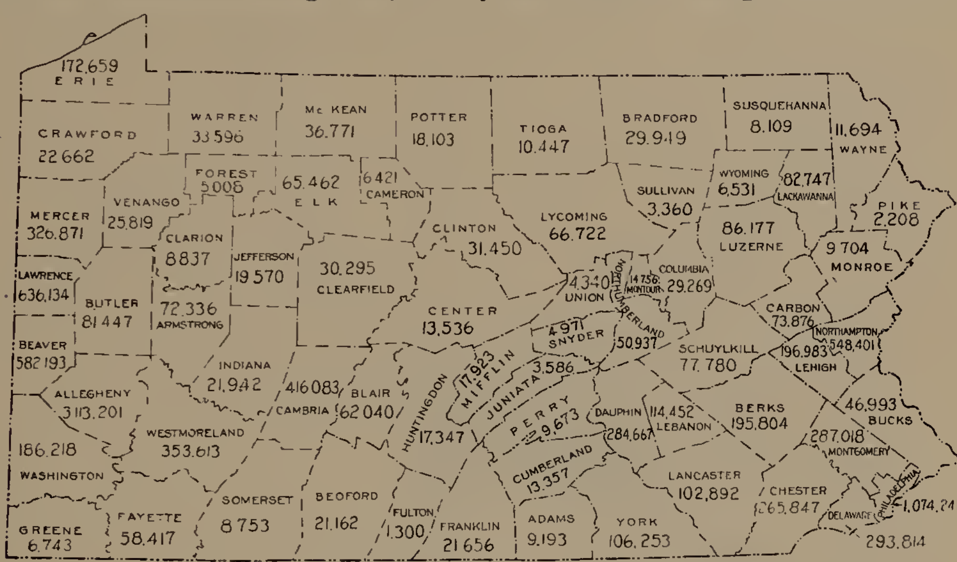


FIG. 9. CONSUMED ENERGY IN INDUSTRY (1922)
Kwh., in Thousands, Consumed in One Year (Exclusive of Mining)

over-populated and therefore more suitable from the viewpoint of economic production and better living conditions.

STAGES IN POWER DEVELOPMENT

The various stages in power development are generally recognized as the small plant with field transmission; larger units of the same type; high pressure steam; the gas engine; the steam turbine of larger capacity; electric transmission and individual drive; and high tension transmission. The most modern installation is confined to the large turbine unit with the high voltage transmission and the electric drive.

There is little question that industrial plants generally are gradually changing to the electric drive and this is true not only in congested centers, but even in the case of isolated plants. The advan-

tages of the electric drive over steam or other drive were promptly recognized. The central stations have expanded their facilities to meet power requirements as well as lighting and traction needs.

Fig. 10 is presented to show this change in the type of installed power in Pennsylvania industry and mining. The outstanding characteristic of this chart is the substitution of electric power for the steam drive. The electric drive includes all motors using either purchased or generated power. A study of power developments to date and probable power developments in the relatively near future would

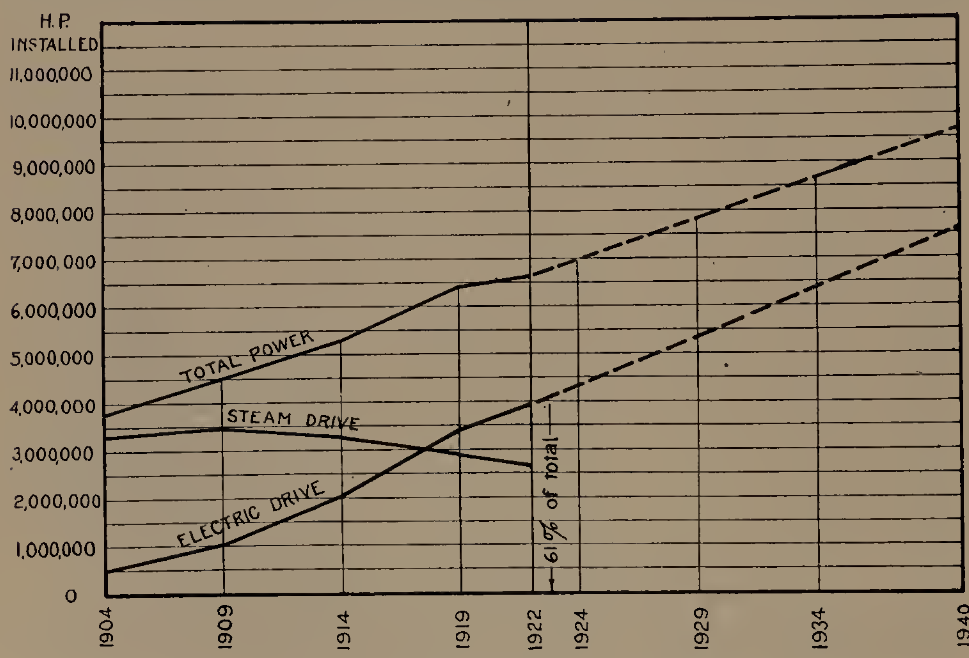


FIG. 10. THE RISE OF ELECTRIC POWER, MANUFACTURING AND MINING INDUSTRIES

lead one to believe that there is in Pennsylvania unusual opportunity to view large scale power development as a primary industry of the State. This is regardless of whether this power is used in Pennsylvania or in any other state. The State which leads in this movement can develop a momentum which will preempt the field.

As to what character of power organization the future will reveal it is difficult to say, but there is no good economic reason why the power consumer should be the power developer or the transmitter of power. Time will probably show the need for three separate activities relating to power, i. e., the Producer, the Distributor, and the Con-

sumer. The Commonwealth of Pennsylvania is concerned with all three fields.

DECENTRALIZATION OF PENNSYLVANIA INDUSTRY ALREADY IN PROGRESS

To be basically correct progress in industry should carry with it the social betterment of the population. The growth of the slum and

FIG. 11. THE PITTSBURGH DISTRICT, 159 INCORPORATED COMMUNITIES

congested city district resulting from the necessity of congregating workers at the source of power has been subject to much justified criticism. With the modern policy of Giant Power permitting the shipment of power to the people rather than the necessity of concentrating the people at the power source, the inevitable slum and congestion is

no longer necessary. Writers generally recognize the desirability of such a movement, but relatively few figures have been presented to show that the movement has started and is under way. That the condition exists can readily be observed by a study of Fig. 11 showing the population distribution within a thirty-mile radius of the center of Pittsburgh. This chart should be studied with relation to Fig. 9.

Using the same area as an example Fig. 12 is presented to show the trend toward the decentralization or at least a limit to further centralizing in the Pittsburgh District. It is to be noted that the rate of increase (the steepness of the lines) is very much larger in the small community than in the big city. The Pittsburgh District has been

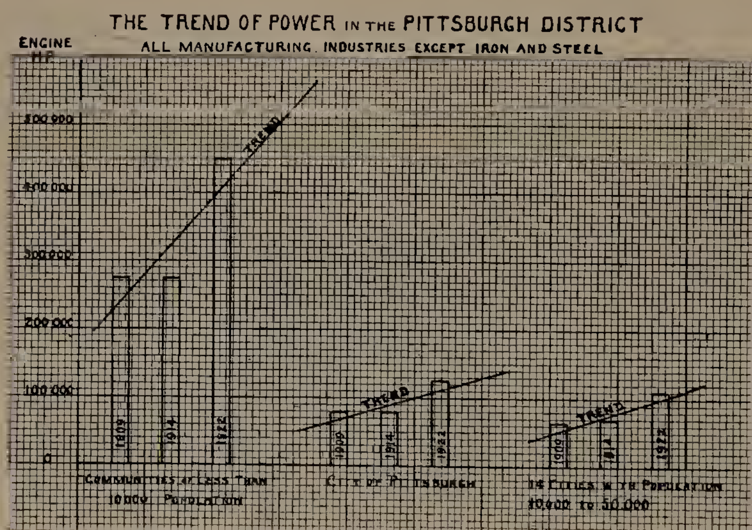


FIG. 12

one of the foremost in developing a major electric power program linking up the various systems and arranging for the distribution of industrial power over large areas.

Fig. 13 shows the trend of installed power in industries throughout the State of Pennsylvania, and is divided into three sections, i. e., the sum of all power in cities over 50,000 population; in cities of ten to fifty thousand population, and in small towns and areas outside of corporate limits. It is to be noted to what a striking extent the increase in power consumption centers in the small community as contrasted with the big city. It is further to be noted that this movement has developed along with the establishment of the central power plant and efficient electric transmission of power beginning say about

1914. It is believed that this movement has only started, largely through necessity, and that with the development of Giant Power, permitting of power transmission over large areas, a dominent influence will be exerted toward improvement in industry and in living and social conditions of all people reached.

Table No. I is presented to show the distribution of Power among the fifteen largest industries of Pennsylvania. The annual capacity factor indicates the percent of total time that the rated load could

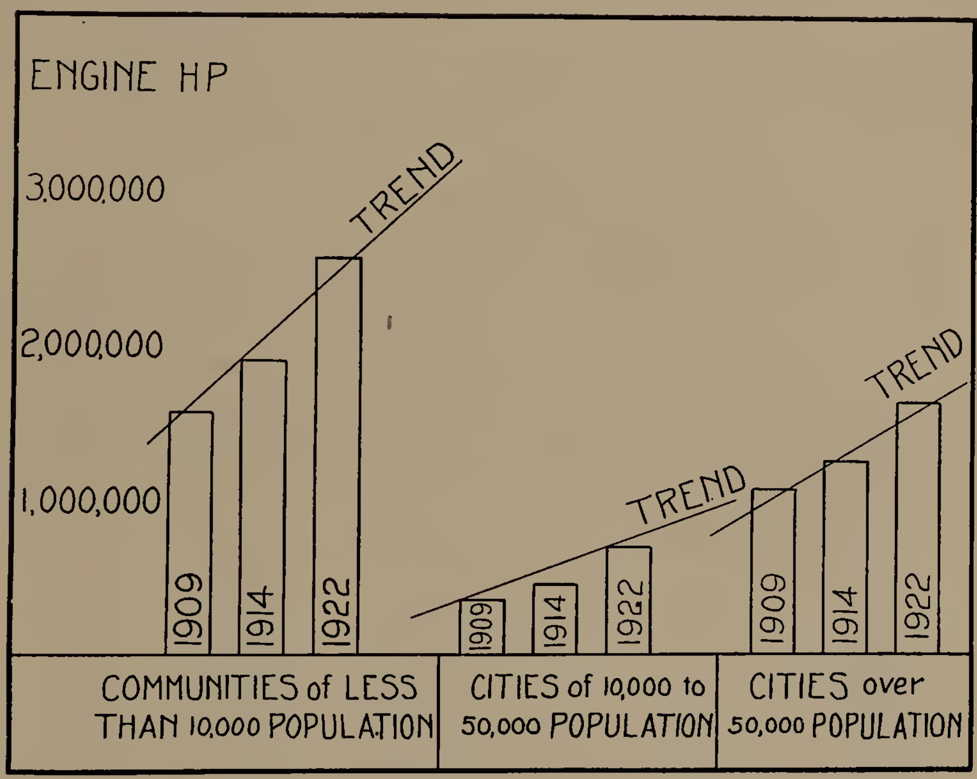


Fig. 13. The Trend of Power in the State, All Manufacturing Industries Including Iron and Steel

have operated. Thus the steel and coke industries operate more continuously than the others, while the mining factor is quite low. From the kwh. column it will be seen that about sixty per cent of the Industrial power is used in the iron and steel industry. In the iron and steel industry of our State important steps toward the more economical development of power and its distribution are in progress and in contemplation. Many of the larger steel plants find that through a more economical use of blast furnace gases in the develop-

ment of power the need of using coal for power development is entirely unnecessary. Plans are on foot whereby these same mills which have an excess of power will arrange with the larger power distribution companies to transmit this excess power to other plants of the same Company, thereby eliminating the need for duplicate transmitting facilities. Plans furthermore are under way whereby excess power from the mills can be absorbed by the large power companies during certain periods of each day and during longer periods of Saturday and Sunday. During other periods of the day shortages of power can be supplied to the mills by the power companies. This movement constitutes an important step toward an integration of industrial power among the various power developing companies, be they industrial institutions or central station power companies.

TABLE I.

DIVISION OF ENERGY CONSUMED IN INDUSTRY IN 1922

	Installed kw.	*Kwh. (1000)*	*Annual Capacity Factor*
Iron and Steel	1,180,620	4,426,853	43%
Blast Furnaces	437,927	2,470,102	59%
Miscellaneous	955,401	1,116,232	13¼%
Foundries and Machined products	248,038	697,483	34%
Coke	56,444	297,601	60%
Cement	76,077	267,411	40%
Paper	64,700	227,737	40%
Glass	54,526	191,659	40%
Railroad Car Shops	70,352	164,835	27%
Clay Products	55,402	160,056	33%
Lumber	67,222	157,501	27%
Silk	57,277	134,200	27%
Electric Equipment	45,282	106,096	27%
Woolen Goods	43,913	102,888	27%
Flour	43,391	101,665	29%
	3,456,662	10,622,319	35%
Mining	1,505,148	2,167,414	16½%
	4,961,810	12,789,733	29½%

TABLE II.

Coal Used in 1922 to Produce Energy Consumed in Manufacturing and Mining

	Short Tons	
For power developed in manufacturing	22,050,000	
For power purchased by manufacturing ...	2,925,000	
		24,975,000
For power developed in mining	4,690,000	
For power purchased by mining	750,000	
		5,440,000
Total short tons		30,415,000

Table No. II is presented to indicate the number of tons of coal which is necessary to develop the power used in Pennsylvania during the year 1922. It is very difficult to find the coal used accurately, for several reasons other than the difficulty of determining the average boiler efficiency and the average quality of coal used. For example, the boiler steam is not always all used for power, part of it often is used for heating or in special process work, which conditions are not indicated on the coal record. It is believed, however, that the figures shown in Table No. II are good approximations.

Trends are World-Wide

While this Survey primarily has to do with Pennsylvania it is interesting to realize that the trends herein indicated are not local but world-wide in effect. The trend in France can be indicated best by quoting from page 223 of "Coal and Power," the Report of an Enquiry presided over by Right Hon. D. Lloyd George, O. M., M. P., Hodder & Stoughton—London, England.

"I restrict myself to modern developments. Accordingly, I consider the devastated regions where, so to speak, there was a clean slate to write on.

"The following table for the devastated areas in the Nord, Pas-de-Calais and Somme show a remarkable drop in the use of steam power, as compared with electricity, in industry. Today the power used is eighteen and one-half percent more than in 1913, but the

amount of steam power used today is only sixty-three and one-half per cent of that used in 1913. Roughly, nine times as much electrical power is now used, compared with 1913. The drop in the use of steam power is particularly noticeable in the textile industry.

"The following table shows the position for the various industries:

TABLE III.

Industry	*Kw. used in 1913*	*Kw. used in March, 1924*	*Percentage of pre-war use*
Steam Generated at—			
Mines	287,500	190,600	66
Iron and Steel Works	119,500	95,800	80
Chemical Works	20,600	13,200	64
Sugar Refineries, food-stuffs, etc.	65,000	44,400	68
Textiles	229,300	111,800	49
Brickworks, Tileworks	26,500	14,200	54
Electric Generators	55,000	481,000	875
Total	803,400	951,000	118.5

NOTE: For the purpose of comparison of steam power with electric power, the H. P.'s of the steam engines have been converted into kw.

The electricity used in these regions wholly comes from either (1) colliery plants, or (2) coalfield power stations. Thus, e. g., the textile works do not generate their own electricity, but connect up with the overhead cables. All cables are overhead, and the absence of precautions, such as nets, is somewhat remarkable."

In England it is interesting to note that because of certain laws passed in 1881 the City of London was divided into some twenty-four districts each one being supplied by a separate electric generating company which was not allowed to exchange power with any of the others. This condition existed down until the time of the war when interchange of power became a necessity and some modifications were introduced. Today, however, there are still a number of companies in London, although the companies themselves are trying hard to combine and hope to do so in the near future. The net result of this past situation has been that the cost of power in London is approximately twice that of Chicago where one electric company supplies the

city. Further there is less than one-half and only a little more than one-third as much power at the elbow of the English worker as there is at the elbow of the Pennsylvania worker. How much bearing the electric situation has on this it is difficult to say but it must be considerable.

CONCLUSIONS

1. In 1922 Pennsylvania used 13,000,000,000 kwh. of power in industry, which was more than the combined industrial power of any two other States in the United States. The rate of industrial expansion in Pennsylvania has been such that the power demand will have about doubled by 1950.
2. With such volumes of power consumption the time is not far off when the isolated industrial power plant, except under peculiar conditions, is doomed, due to the limits of coal transportation, water supply sites, and cost of power production when compared with the central station plant of the capacities contemplated by Giant Power.
3. If industry is to maintain its growth power must be transported to industry from Giant Power plants economically located rather than to move industry to power.
4. There must be an integration of all power supply permitting of easy exchange.
5. The movements indicated under 3 and 4 already are under way.
6. Industry and population in Pennsylvania today are restricted to relatively few counties. Giant Power will make it possible to draw people engaged in industry away from the slums and congested industrial centers.

Technical Report No. 3

NATURAL RESOURCES AVAILABLE FOR POWER

By F. H. NEWELL,

Consulting Engineer and Formerly Director U. S. Reclamation Service

With over 43,000 million tons of coal to be had from the ground enough for 250 years at the present rate of use, and with 700,000 water horse power to be had from rivers flowing idly to the ocean, it is plain that the citizens of Pennsylvania have a right to expect cheap and plentiful electric power. This expectation may be realized; not only more electric power can be had, but this can be done in such a manner as to bring about a higher conservation, as well as use, of these natural resources, including the saving of by-products from the immensely valuable volatile substances contained in bituminous coals. These coals must be used in an ever increasing quantity because even if all of the rivers of New York and New England, including that part of Niagara and of the St. Lawrence River allotted to the United States were utilized for power production, there would still be a demand for Pennsylvania coals.

Giant Power Stations—Giant Power plants of a size warranting the use of the largest and most efficient generating units, aggregating, say 650,000 horse power to the station, with by-product recovery, can be located in Western Pennsylvania near beds of bituminous coal along the rivers, where there is adequate condensing water and a fuel supply sufficient for fifty years continuous operation.

Thus placed near the mines it becomes possible to put to use much

DR. NEWELL, first director of the U. S. Reclamation Service, organized in 1907 for the purpose of extensive irrigation work in the West, is a consulting hydraulic engineer. For 17 years he was associated with the U. S. Geological Survey, and for 5 years its chief engineer. During 1915 and the four years following Dr. Newell was head of the Department of Civil Engineering at the University of Illinois, and at present is a member of the Water and Power Resources Board of Pennsylvania. He has written quite extensively on the problems of development and use of the resources of the country. Past President of American Association of Engineers and Washington (D. C.) Society of Engineers. Home: Bradford, Pa.

of the coal of inferior quality, or of high ash content, which otherwise might be neglected or thrown aside because of the expense of a long haul. The location of the Giant Power plants, however, is determined not so much by the quantity and quality of the coal as it is by the readiness of access to water for steam condensing purposes. With present methods of generating electric power by steam, water in sufficient quantities to maintain as high a vacuum as possible is necessary for efficient power production and, dependent upon the temperature of the water, may require upwards of 400 tons of water to one ton of coal. For this reason the coal for steam power production must be taken to the water. In Western Pennsylvania, where most of the volatile coals are found, nature has provided large streams, and even though these rivers have a small summer flow, yet the ingenuity of engineers is finding ways of storing the floods or of using over again a second or a third time the scanty supply available at certain seasons.

Neighborhood of Coal and Water—The Allegheny River coming from the North and the Monongahela from the South, uniting at Pittsburgh to form the Ohio, all navigable for coal barges, or to be made so in the not distant future, receive the flow from a wide spread system of rivers and creeks which extend throughout the bituminous coal region. Every mine is near some stream and all these streams help to furnish water available ultimately for cooling purposes at power plants to be located at points where the total natural flow, increased possibly by storage in reservoirs, is adequate for economical power production.

Using coal at the mine, avoiding the cost and waste of transportation, utilizing the poorer fuels and saving all possible by-products has long been the ideal toward which economists have aimed. Steam electric plants of considerable size have thus been located at the mines with a short haul—two to five miles from the heading in the mine to the coal bunkers of the power plant. A large and steady supply of fuel, the insurance of continuity of operation, may be had in this way by connection with several adjacent mines or openings within eight or ten miles of points suitable for Giant Power plants on Allegheny, Monongahela and Ohio Rivers. From the tipple at each mine mouth to the bunker of the power plant the cost of haul by railroad usually down grade, is from 2 cents to 3 cents per ton mile for distances of 5 to 15 miles. The total costs of the relatively short hauls from mine to near-by power stations are obviously not comparable with the

greater expense, \$2.25 to \$3.50 per ton, of transporting bituminous coal for 300 miles or more to the seaboard.

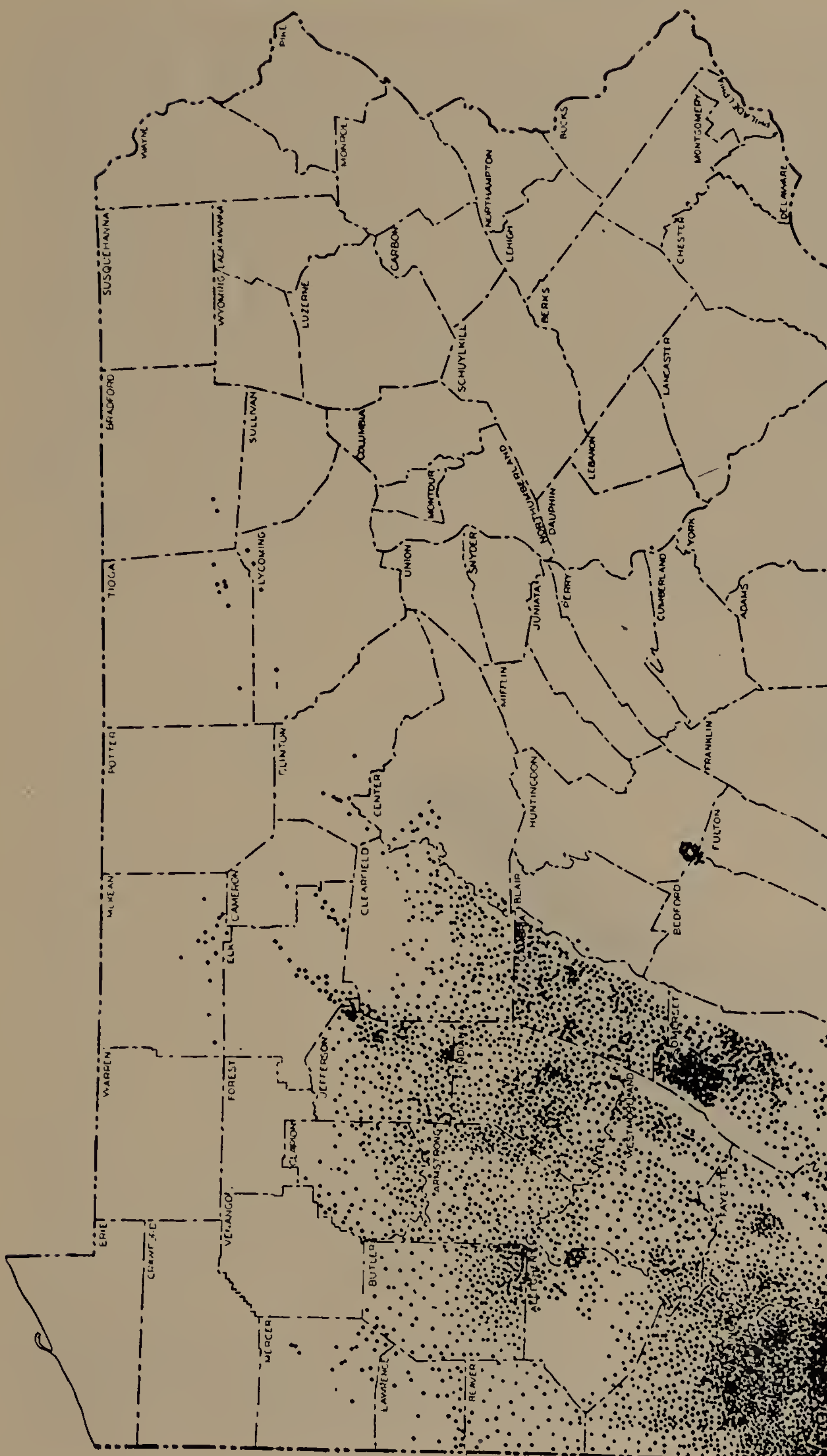
Ample Coal—Pennsylvania leads in the production of coal. It has great reserve stores of fuel to be had by mining. It is now supplying and will continue to supply for decades the larger part of the coal used in the industries of the great manufacturing area of the United States. As regards gross quantity we need have no doubt as to the existence of adequate supplies of fuel for every probable demand of this and the next century. What we should be concerned with is not the limitations set by nature, but rather the ways in which these bounties of nature may be used for the greatest good to the greatest number of our citizens and not needlessly wasted. At present the rate of mining of bituminous coal is 170 million tons per year. If this rate is continued, there will be enough coal for 250 years.

In this connection, it should be noted that the more easily available coals, the thicker beds and those nearest the surface, have been first mined, and that as time goes on the difficulties of mining increase. This is accompanied by a greater cost of coal extraction, excepting in so far as this greater cost may be offset in part by improved methods and greater economies.

In the process of mining the 5,000 million tons or more of coal already extracted, other thousands of millions of tons have been left in the workings, often to support the roof but usually because the coal was inferior in quality; high in ash, "bony" or otherwise unmarketable. Much of this low grade coal in mines near Giant Power plants may and should be utilized, thus reducing the average fuel cost.

Adequate Condensing Water—The selection of sites at which Giant Power plants may be located is controlled largely by the facts as to quantity and quality of water available at all times. It is from this standpoint of an ample and dependable supply of water for condensing purposes, as well as for water for hydro-electric development, that a full study of the streams of Pennsylvania is needed.

In their natural conditions the rivers of Pennsylvania, even those ordinarily of considerable volume, shrink during the summer to a tenth or less of their ordinary flow. At such times power plants, so far as condensing water is concerned, are necessarily limited in their efficient operations. For high efficiency in a Giant Power plant, as just noted, 400 tons or more of water during the extreme period of warm weather are required for each ton of coal consumed. This water



BITUMINOUS COAL RESERVES IN PENNSYLVANIA
Each dot represents ten million tons.

Prepared by James D Sisler
Pennsylvania Topographic and Geologic Survey

FIG. 1

is needed for cooling or condensing the steam after its expansion in the steam turbine. During expansion, the heat of the steam is largely converted into energy, and the water vapor is partly cooled, but not sufficiently to make available all of its energy. To get the greatest possible amount of energy out of the fuel burned, the steam must be still further chilled by some means. Commonly this is done by using enormous quantities of river or sea water to condense the steam, by this means bringing about a partial vacuum in the exhaust chambers of the steam turbine. The resultant pressure is thus less than that of the outside air. The latter is about 15 pounds to the square inch, or enough to sustain a column of mercury to a height of 30 inches. The attempt is made to maintain in the exhaust chambers as nearly a complete vacuum as possible to prevent back pressure and to secure the greatest efficiency of the steam. Under favorable conditions the final pressure can be maintained as low as 1½ inches of mercury or less, that is to 28½ inches of vacuum.

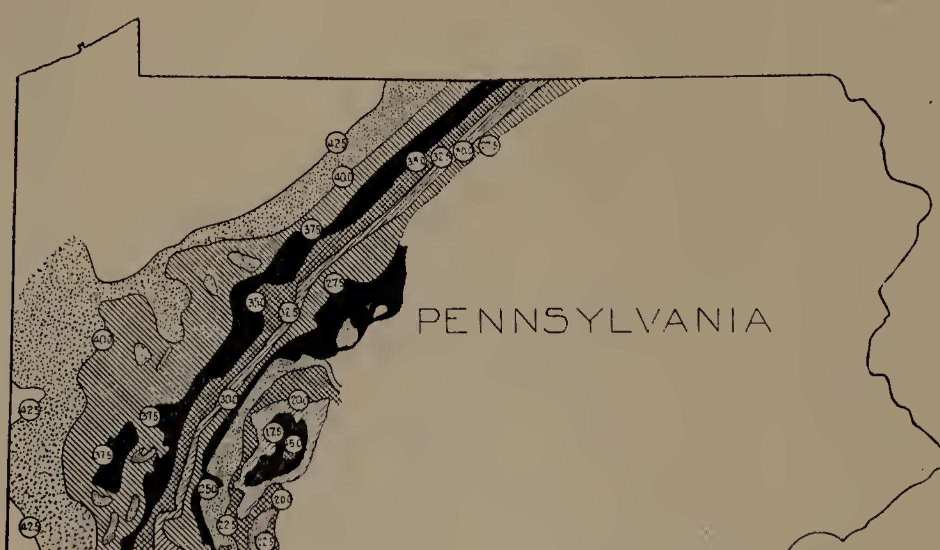


FIG. 2. LOCATION OF BITUMINOUS COAL DEPOSITS OF DIFFERENT VOLATILE CONTENT

The percentage of volatile matter is shown to decrease from 42.5% and over, in the extreme western part of the State to 15% or less toward the eastern or more highly disturbed portion of the coal fields.

The temperature of the cooling water controls or sets a limit to the amount of water required to obtain a given vacuum. With the exception of a short period during the summer a sufficient volume of cold water is available at numerous localities in or near the coal fields. The necessity of continuous operation through the year, however, requires that suitable provision be made for such periods during the hot weather when not only the temperature of the water is high, but also the natural flow of the stream is low. To provide sufficient water at such time cooling by sprays, towers and other devices[1] can be resorted to, and the operation conducted temporarily on a less efficient basis. The effect of this for short periods is of minor importance when the low cost of fuel is taken into consideration, as compared to a plant at tidewater using high grade coal with transportation charge added.

The usual way of describing a river is by the rate of flow, the unit employed being the cubic feet of water passing for each second time. A stream 500 feet wide and 2 feet deep moving at the rate of 1.0 foot per second will deliver 1,000 second feet or about the ordinary flow of Juniata River at Huntingdon. This steady flow of 1,000 cubic feet per second at a temperature of 60°F. when put through the condensers or cooling devices is adequate to maintain a vacuum of 28¼ inches. This, with a coal consumption of 10,000 tons per day is enough for the production of 650,000 H.P. If the temperature of the river water rises to 70°F., then with 1,000 second feet river flow the vacuum will drop from about 28¼ inches to about 27 inches, with corresponding reduction in the efficiency of the plant. To get back to this ideal vacuum, the volume of the cooling water must be increased to 1,500 cubic feet per second or more. Can this amount be had by storage or otherwise?

Water Storage—The larger rivers of Pennsylvania have their headwaters outside the State. The Delaware, Susquehanna, and Allegheny originate in part in the State of New York and in regions which in former times were covered by glaciers; these have left a number of lakes some of which have been, and others may be, utilized for reservoirs. Throughout the greater part of their course in Pennsylvania these rivers as a rule occupy narrow valleys in which rail-

[1]For discussion of this subject see Appendix C IV "Water as a Factor Influencing the Location of Giant Power Plants" by August Ulmann, Jr.

roads have been built. Thus it is quite difficult to find suitable places for the creation of reservoirs. Yet as on Clarion River, a tributary of the Allegheny, there are several localities where dams are being built or will be built in the future.

These present and prospective works for regulation and control of the rivers within or outside the borders of Pennsylvania, while intended primarily for hydro-electric development, tend to smooth out the natural flow of the streams in the State, decreasing the destructive spring floods and increasing the low water discharge. Some of the proposed improvements are designed primarily for flood protection such, for example, as those which have been reported upon by the Flood Commission of the City of Pittsburgh. Other works are designed primarily for navigation purposes, such as, the building of locks and dams on Allegheny River similar to those constructed on Monongahela River. These tend to hold back the low water flow in pools of from 5 to 15 miles in length and thus enable a better use of the water for condensing purposes.

Taking in review all of the rivers of the State and having in mind the natural facilities for large power stations, it is apparent that because of the propinquity in large volume of high volatile or bituminous coals and of water supply, the Allegheny stands first. Many of the poorer coals, hardly worthy of shipment will find their best use in local power plants along this stream. There are advantageous localities to be found notably below the mouth of the Clarion River from Kittanning south down stream for about 25 miles, to the vicinity of Freeport, below the mouth of Kiskiminitas River. The ordinary flow of the river in this stretch of 25 miles is 2,500 cubic feet per second. The floods amount to 200,000 second feet and in the natural condition the lowest summer flow averages 1,160 second feet and has dropped to 570 second feet. With the completion of the reservoirs built for hydro-electric purposes on Clarion River, there will be insured a minimum flow of nearly 2,000 second feet. Moreover, the construction of navigation dams already under way will insure the maintenance of pools of such magnitude that even though the flow from Clarion River reservoirs should be temporarily checked, there will still be enough water to enable the efficient operation of the cooling devices of Giant Power plants.

Although the valley of the Allegheny River is narrow and both banks are occupied by railroads, yet there are a half dozen or more

places where an area of land now unoccupied could be found adequate in extent for a Giant Power plant including space for buildings for by-product or related industries and for storage yards.

On both sides of the river coal occurs at intervals in the bluffs. The mines as yet are relatively small and the coal beds have not been thoroughly explored by drilling, but it is known that there are a number of beds of from 3 to 6 feet in thickness. It has been estimated that in Armstrong County, mainly on the east side of the river, the total recoverable coal amounts to approximately 2,490 million tons.

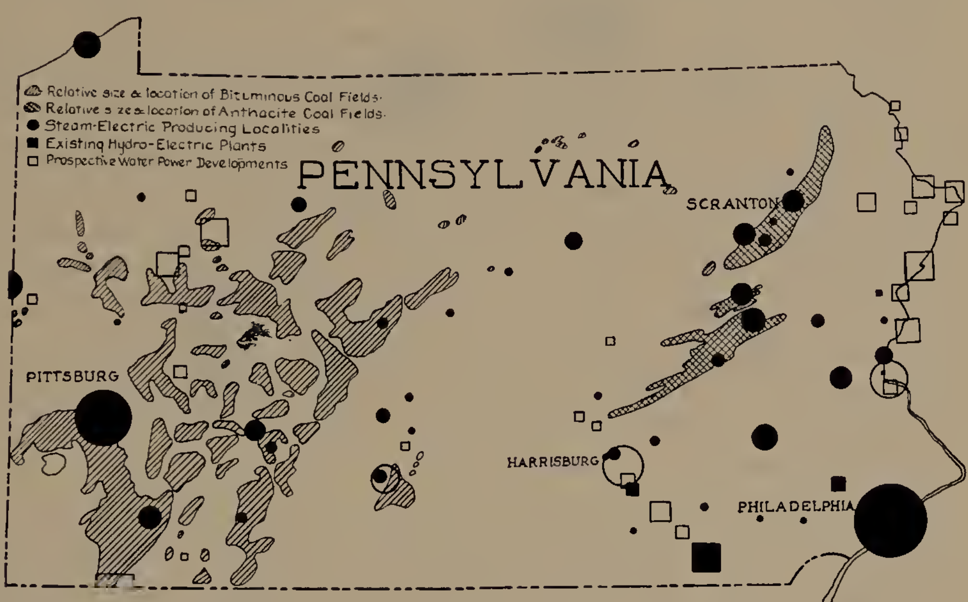


FIG. 3. COAL FIELDS AND POWER PLANT LOCATIONS IN PENNSYLVANIA

The single cross hatched areas show the relative location and size of the bituminous fields; the double cross hatched are the anthracite fields. The circles indicate the principal steam-electric producing localities and the squares in solid black, are the existing hydro-electric plants; the squares in outline only are prospective water power developments.

Similar statements may be made regarding the Monongahela River. Here industrial development has already taken place to a larger degree than on the Allegheny. The navigation dams and locks have been completed and in use for many years. Work has been begun on a dam for a large reservoir located on Cheat River near its mouth immediately south of the Pennsylvania State line. From this dam, and from a reservoir to be built on Big Sandy River in West Virginia,

a steady flow of 1,500 second feet will be available throughout the summer season.

The coals along Monongahela River have been mined to a larger extent than along the Allegheny. The best of these, the Pittsburgh bed, has been worked out in the more accessible localities, but there are millions of tons back from the river, to the west, which may yet be had. The lands underlaid by coal best for coke for metallurgical use, have been bought up by the large steel companies, but there are known to be other beds which will be available for fuel for power purposes.

Below the junction of the Allegheny and Monongahela Rivers at Pittsburgh, forming the Ohio River, are several large steam electric power plants, erected or contemplated, approaching Giant Power in size. The coal in the immediate vicinity of this river has been largely mined, but almost unlimited quantities of bituminous coals of many qualities can be had from the mines along the Allegheny and Monongahela Rivers, brought down by the use of the barges, as well as by rail from adjacent inland areas. Farther down the Ohio River at Windsor, W. Va., is the large generating plant of the West Penn Power Company deriving fuel from adjacent mines. Other plants may be similarly located at suitable points along the 35 miles of the Upper Ohio which is in Pennsylvania.

Next in order of importance as regards possible sites for a Giant Power plant is Susquehanna River and its tributaries. The valley along the main stream is wider than on the Allegheny or Monongahela Rivers and there are many places where ample space can be found for the necessary buildings for a Giant Power plant. The water supply as a whole is large, particularly below the junction of the North and West Branches. The ordinary flow at Sunbury, located at this junction, is 6,000 second feet and at Harrisburg 50 miles farther down and below the Juniata is 7,000 second feet; the floods reach a maximum of 400,000 second feet, while the summer flow at Sunbury had dropped to 1,200 second feet and at Harrisburg to 2,330 second feet. During 30 years the flow has been below 3,000 second feet for about 30 days.

The coal necessary for Giant Power stations on Susquehanna River can be obtained either from the anthracite region or from the bituminous areas in Clearfield and adjacent counties. A railroad haul

of from 50 to 100 miles is necessary in order to bring the coal to the water of the main streams. There are other possibilities of building power stations on the larger tributaries.

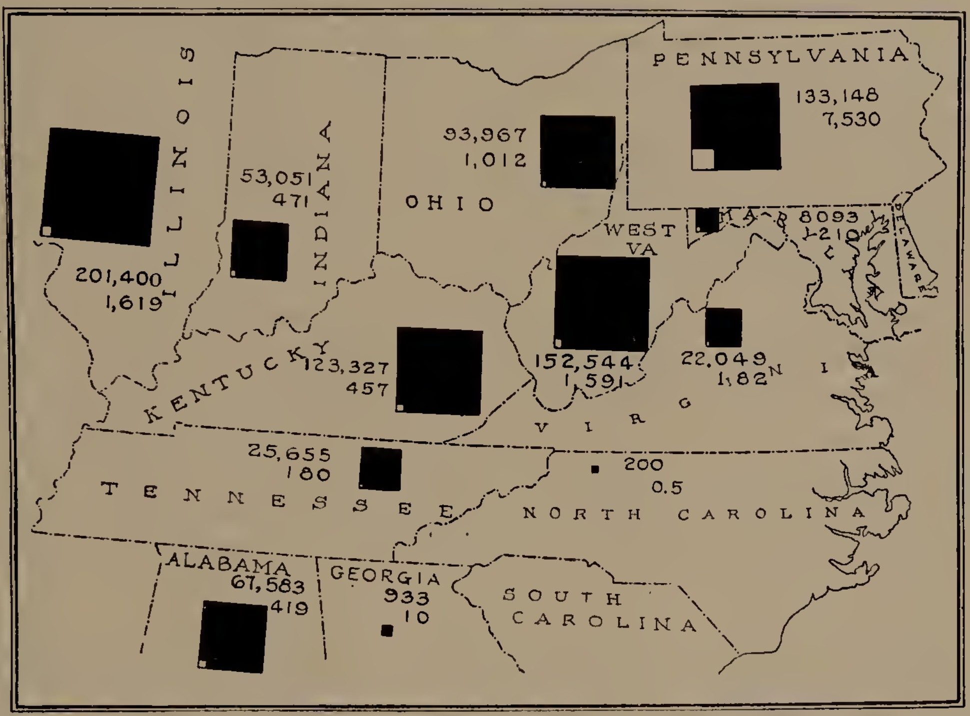


FIG. 4. AMOUNT OF COAL AVAILABLE IN CENTRAL AND EASTERN UNITED STATES

The large black squares in each State give the relative tonnage in the ground down to the 3,000 ft. level, as shown in the upper set of accompanying figures in millions of tons. The small white squares in the lower left hand corner of each black square shows the relative amount mined to date, as given in the lower row of figures. That is in Pennsylvania, there are estimated to have been 133,148,000,000 tons of which 7,530,000,000 have been mined.

Anthracite—A peculiar interest attaches to the possibility of using in the production of electric power some of the great piles of waste so conspicuous throughout the anthracite region. Everyone who visits this part of the State comes away with the expressed belief that something should be done to put to use the coal apparently wasted in these mountain-like accumulations of black debris. "Not all is gold that glitters" and "not all is coal that is black." Most of these black piles consist mainly of rock or bone, that is of a poor or inferior coal with a prohibitory per cent of ash-forming materials, but some

of them have enough good coal, usually of fine size, to be worthy of consideration.

Anthracite is not only a highly valuable or "luxury" coal but is limited in quantity. It is found in large commercial quantities only in Northeastern Pennsylvania. The original deposits are estimated to have contained over 20,000 million tons of coal of which nearly one-fourth has been taken from the ground or wasted in mining. At present the rate of mining is approximately 80 million tons per year. It is estimated that with a loss in mining of 40% about 8,000 million tons may be recovered.

Unlike other coals, anthracite does not occur in nearly level beds. As a rule the rocks which contain it have been greatly bent or folded; it is because of the heat and other results of this folding that this coal is deprived of its original volatile contents, characteristic of bituminous coal and is now left as nearly pure carbon. Due to the fact of this folding, the methods of mining are quite different from those of the ordinary coals. Large quantities of rock must be taken out with the coal and in some mines 40% of the material hoisted is rock.

Of the coal itself a large part has been crushed by natural forces, some of it to powder. Even where not broken by the folding or crumpling of the rocks most of the coal is shattered in mining so that fully 35% of the anthracite which in the past has come from the mine is in sizes too small to have ordinary market value. The public has become accustomed to using certain sizes commonly known as egg, or stove coal and is reluctant to try to use the smaller sizes, all equally good as fuel, but too small for the mechanical devices or grates commonly used for heating purposes. Because of this condition a large part of the pure anthracite taken from the mine has been thrown out with the rock and bone, or coal of high ash content, forming these miniature black mountains, characteristic of the anthracite region, locally known as "culm" banks. The older banks contain from 20 to 30% of coal, some of it of stove sizes. During the acute demand for coal in recent years many of these culm banks have been reworked and the valuable coal put on the market.

Culm Banks—Assuming that adequate fuel can be had from these culm banks and from continuous mine waste, the question here as elsewhere, as regards power development, is that of cooling water. The only place immediately adjacent to the anthracite region where

it appears that there may be enough water for a station, is on the North Branch of the Susquehanna River near Pittston. In the other direction, going down stream the best locality is on the main Susquehanna River below Sunbury and from these on down to Harrisburg. This also has the advantage that in case of exhaustion of anthracite waste coming from the East, it will be possible to bring to a large plant the bituminous coal from the West. Wherever used the fuel must be gathered from many mines and shipped by rail to the cooling water for distances of from 20 miles to 100 miles.

The cost of obtaining coal from these culm banks varies greatly with the age and consequent character of the banks, their size and location. The cheapest cost given has been 35c a ton, the highest $3.00, the average $1.50. In proportion as the older and richer banks are washed, the average expense of getting coal from the poorer banks necessarily increases.

Taking all of the anthracite area, it has been estimated that 65% of the coal mined is readily marketable, that is, can be had in sizes known as broken, egg, stove and nut, the prices for which to the consumer are approximately $15.00 per ton. Of the smaller and less salable sizes, the proportions are pea—9%, buckwheat—12% and smaller—14%, total 35%. Most of the 35% of good anthracite has been practically thrown away in the past or has been consumed at the mine for power, usually in a wasteful manner. Some is being held indefinitely for future use at the mine or for possible sale if the demand increases for powdered fuel or for briquettes. It is this margin which should be considered in connection with Giant Power development.

Amount of Culm Available—The best estimate made of culm or small sized coal in the waste banks at the mines in the anthracite region was made for the U. S. Fuel Administration in February, 1919. This placed the total available merchantable coal in the culm banks of the anthracite region at approximately 50,000,000 tons of which not exceeding 20% or 10,000,000 tons should be pea or larger sizes. That is, coal which would not pass through a half-inch opening.

During the five years which have lapsed from 1919 to 1924 there has been considerable activity in the working of the older and richer culm banks so that Mr. R. V. Norris, who prepared this report, estimates that in 1924 there are possibly 30,000,000 tons, mainly of sizes less than ½ inch in diameter, scattered over 100 different banks,

distributed throughout the entire anthracite region at an extreme distance of 80 miles. There is no way of ascertaining how much fuel may be obtained from these banks. Those which are known to be most valuable have already been worked and at others washing has been stopped because of the large amount of rock and bone which must be handled. In a few cases these culm banks have caught fire and much of the coal has been consumed. Taking into consideration the scattered location of these banks and the fact that the richest of these have been exhausted, it is a fair approximation to assume that it may be practicable to recover 20,000,000 tons of fine anthracite at a cost of about $1.50 per ton. In addition to this is the cost of about $1.00 per ton of loading and hauling from scattered points to a central power plant.

Besides the fuel which has been left in these culm banks there are certain recoverable wastes. Under present mining methods about 15% of the anthracite now being mined is added to these culm banks or consumed in mine power plants. In other words 12 million tons of fine coal and dust is being thrown aside or wastefully used at the mines. It is proper to assume that with the construction of large central power stations or Giant Power plants many, if not all of the mines, will obtain power more cheaply or conveniently than they can produce it and thus release much of the coal now burned by them for mining purposes.

Increase in efficiency should result if the mine operators would prepare anthracite for domestic purposes only and hold back for use in Giant Power stations all small sizes, now inefficiently used for steam production. Under these conditions by bringing the freshly mined small and unmarketable coal sizes from say 20 of the larger and more conveniently located mines, and by supplementing this with fuel washed from the richer culm banks it is possible to assume the existence of enough fine anthracite to supply one or possibly two Giant Power plants consuming upwards of 10,000 tons a day. The problem is complicated, however, by the fact that vigorous efforts are being made to educate the public to the use of these small sized coals.

Water Power—Water was the first important source of power available in milling and mining. When Giant Power is mentioned most people think of hydro-electric energy but few appreciate that only about a tenth of the energy produced or used in Pennsylvania

comes from water power and that there is little probability of this proportion being materially increased. The stream flow continually renewed by rain, in contrast to coal burned in the steam boiler seems to cost nothing and is indestructible. The question is asked again and again "Why should coal be mined and destroyed to produce steam power when such vast floods of water roll down the river beds, and perform no useful work, other than to carry away our municipal and manufacturing wastes?" The answer lies in the fact that there is not enough water for all needs, also that the water does not always flow when most needed; water plants are usually more expensive to build than steam plants. More than this they are not regular in their performance. Power to be valuable must be constant; to get a steady supply of power the water wheels must be supplemented by steam engines. The ideals of Giant Power, however, involving the pouring of power into a great "pool" and taking out power to supply deficiences, make possible a larger and more economical use of these water powers.

To ascertain the potential water power for any river it is necessary to make certain assumptions regarding the limitation imposed by nature, for example:

(a) The maximum potential water power is based on the flow available for 50% of the time during which the flow has been ascertained. This is a little less than the average flow for the entire period because the average includes the extraordinary floods which raise this figure.

(b) The minimum potential water power, as agreed upon, is based on the average flow for 15 days of the lowest discharge of the stream.

The estimate prepared by the U. S. Geological Survey indicates that a total of 170,000 horse power have been developed out of a minimum, as above defined, of 275,000 horse power and of a maximum without storage of less than 700,000 horse power. Thus the State in its potential supply possesses not far from 1% of the total water power available in the whole United States. Its area is about 1½% of the total area of the whole. So far as actual use is concerned the steam engines have supplied in recent years over 4,000 million kilowatt hours while water wheels have furnished less than 500 million kilowatt hours or about 11 per cent of the total power generated.

Up to the present time the development and use of the rivers of

Pennsylvania has proceeded somewhat slowly due mainly to obstacles interposed, not so much by nature, as by incomplete or defective laws or the complications arising from state boundaries.

Delaware—Important works have been begun on the tributaries of the Delaware. This river offers peculiarly interesting problems for although it does not have a flow as large as that of the Susquehanna River, it is capable of considerable development. Such use has been prevented by the fact that three states are concerned with the distribution and use of the waters and no action can be taken materially modifying the condition of the stream without the assent of each of these three states of New York, New Jersey and Pennsylvania. A compact authorized by the legislatures of these states has been prepared to insure this joint action.

Delaware River has its source in the Catskill Mountains in New York. The drainage area above Port Jervis where the States of New York, New Jersey and Pennsylvania join, is 3,250 square miles. The flow at that point ranged from 180 second feet in September, 1908, to a maximum of 84,000 second feet in 1913. Between Hancock near the north line of Pennsylvania and Belvidere, New Jersey, above the mouth of Lehigh River, a distance of 125 miles, there is a fall of 675 feet. The water power development proposed, is to be effected by means of a series of dams each of which will back up the water to the next site above. It is planned ultimately to develop 12 sites on the main river, one on Wallenpaupack Creek, Pa., one on Shohola Creek, Pa., and one on Mongaup River, N. Y. This power development is hampered in places by the presence of railroad tracks along the banks of the stream.

Up to the present time the Delaware River has not proved favorable for the development of hydro-electric power on account of the extremely low water flow during the summer, but it is evident that by construction and uses of reservoirs at the headwaters of the river, and its tributaries a large amount of power may be had throughout the driest season. This is especially notable if these reservoirs and water powers are operated under unified control and the power plants are tied together by interconnecting transmission lines. Such reservoir construction and river regulation might not be economically feasible for water power alone, but for municipal supply, power and other purposes combined they may be of great value.

Susquehanna—The Susquehanna River, as regards opportunities

for water power development, differs widely from most streams of the country. As a rule the greatest fall of any river, and consequently the best opportunities for hydro-electric development, are relatively high up near the headwaters. In the case of this river, however, the greatest available fall is near its mouth about 25 miles above the point where it empties into Chesapeake Bay. Here at McCall's Ferry or Holtwood a dam has been built across the stream and a generating capacity of about 90,000 kw. installed. Nearly 15 miles further down river near Conewingo in Maryland is another power site which may be developed to equal or greater capacity.

Above these larger developments and below Harrisburg is the water power at York Haven, 15,000 kw., utilizing one of the channels of the river and still further up on the Frankstown Branch of the Juniata at Warrior's Ridge is a dam developing 3,000 kw. There are relatively few opportunities for water storage on a large scale on any of the tributaries but it is possible that after careful search there may be found favorable localities for smaller works.

Ohio—On the headwaters of the Ohio River, that is, on the Allegheny and Monongahela and their tributaries, are opportunities for water storage and development of upwards of 300,000 hydro-electric horsepower. The most important of these are on the Clarion River as before noted, also on the Monongahela. The latter within the state is navigable, but upstream and across the state line in West Virginia are several possible reservoir and hydro-electric sites. Work at one of these, at the mouth of Cheat River, is now progressing on a dam which may furnish 100,000 horse power.

It is to be noted that the value of these reservoir sites and hydro-electric plants is dependent upon the way in which the power be interconnected with various systems of electric power generation and transmission. Each water power when considered by itself and as an independent unit may not be capable of returning the cost of the investment but when used in connection with municipal water supplies and with a number of other sources of power, then its potential value is increased and the results may well justify the cost. If the water for any hydro-electric plant can be stored, then this becomes of especial value in supplying peak load demands. If on the contrary there is no storage and the power must be used whenever water is available, then the hydro-electric plant may carry a base load, limited by the river flow, and the peak demand may be met by auxiliary steam

plants. The value in each case is directly dependent upon or is increased by being a part of a co-ordinated system.

The point to be emphasized is that the water and fuel resources of the state and of adjacent states can be used to the best advantage of the public when there has come about the most complete development possible of water storage and of interconnected electric transmission systems, all integrated in such way as to be capable of pouring a supply into practically one great pool of power and all so controlled as to enable each unit to perform its highest service with reference to time and quantity of demand for power. Viewed as a whole, the ultimate development of water and fuel resources can only come about through the adoption of the principles of complete integration and interconnection with resulting co-ordination of these natural resources.

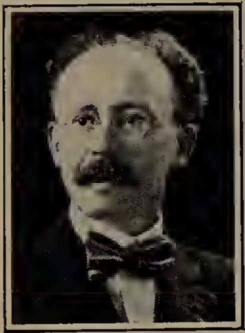
Technical Report No. 4

PRETREATMENT OF BITUMINOUS COAL

THE WAY TO CHEAPER POWER AND TO CONSERVATION OF THE GREAT AND DIVERSIFIED VALUES OBTAINABLE THEREFROM

By JUDSON C. DICKERMAN, *Ass't Director, Giant Power Survey*

When in 1923, after experimental plant trials, Henry Ford started the installation of coal treatment plants to obtain gas, oils of various qualities, tar and other substances, before burning the hundreds of tons of bituminous coal daily required for the power plants of his principal factories, a new epoch in power production was inaugurated. Power engineers have applied much intelligent energy and spent millions of dollars in perfecting equipment to control the combustion of raw bituminous coal so that the largest possible number of heat units, including the particularly fugitive heat units in the one-third highly volatile constituents of raw coal, might be corralled in the steam of the boiler for conversion into power. Their efforts have resulted in cheaper power. Meantime science and practice demonstrated that the volatile components of bituminous coal were more valuable for other purposes than as mere boiler fuel when properly extracted from the coal as tar, oils, gases, etc. So the approach by Ford to the problem of most efficiently and economically utilizing the full potential values of bituminous



JUDSON C. DICKERMAN is a graduate of the Massachusetts Institute of Technology with ten years experience in factory operation including supervision of processes, efficiency of production and cost calculations. For two years prior to taking up his work with the Giant Power Survey he was General Manager of the Roanoke, Virginia, Water Works serving a community of about 60,000 people. He has had seventeen years of public employment as engineer in supervision and regulation of public utility service particularly with reference to street lighting, and gas and electric service, and giving especial attention to the economics thereof as affecting the public interest. This service extended to the United States Government, the state governments of Wisconsin, Virginia and Pennsylvania, and such cities as Chicago, Philadelphia, Cleveland, Newark, N. J., Springfield, Ill., Malden, Mass. and Bradford, Pa.

coal marks a new course for power and heating engineers to pursue in arriving at cheaper power. This course has plenty of scientific logic behind its as being the best way to make our great but not inexhaustible deposits of bituminous coal contribute their maxima to human progress and to satisfy human desires.

Not only must the power industry, highly organized, with trained personnel and using large amounts of fuel at concentration points, soon pretreat its bituminous coal, but those large quantities in the aggregate, of solid fuel, which are needed for domestic and industrial uses, must be pretreated before distribution to the end that the by-product values be saved, and that the smoke evil, from which we all suffer such serious but apparently otherwise unavoidable losses to property and health, may be abolished.

Science has, with cumulative force, pointed the way to conserve these varied and important values in bituminous coal, until now we may reasonably expect soon to see the day when all bituminous coal must and will be treated to recover its by-products and little or none of it be burned raw, either in industry or the homes of the land.

Sir John Cadman, President of the British Institution of Mining Engineers has stated "A very few years may see it a penal offense to burn raw coal in any of our towns. . . . While the popular view of coal is that it is something to be burned, the scientific view is tending to be precisely the opposite. It is that coal is too valuable to be burned, that to burn it is to squander it, that the by-products of coal (ammonia sulphate, benzol, creosote, tar, gas, and crude light oils) are of greater moment than the coal itself and that not until these by-products have been extracted, should the residuums (*i. e.*, the heat producing constituents) be used."

That Mr. Ford is not alone in this expectation of cheapening power by extracting from bituminous coal these valuable by-products, is shown by the facts that near Newcastle, England, a large power plant has installed a process to predistill soft coal before it generates electric power, the details of which are not yet made public; decision has been made to install six MacLaurin gasification with by-product recovery units at the large Dalmanock station, Glasgow, Scotland, while pretreatment plants are being installed at the large Golpa plant located at the mines and supplying most of the electric power used in Berlin, Germany.

Next to the intelligent industry of its citizens, the greatest asset

THE NEGLECTED OPPORTUNITIES INVOLVED IN THE WASTEFUL USE OF COAL IN THE UNITED STATES
Table I p. 113. Bulletin 102, Vol. 1. Smithsonian Institution (1919)
By Chester G. Gilbert and Joseph E. Pogue

All figures in round numbers and on an annual basis.

Present Attainment		**Possible Attainment**					
Coal inadequately used under present conditions (1918).	Recovered under present conditions	Available under present technical knowledge and ultimately recoverable under stimulus of constructive economic policy.		Loss interpreted in terms of dollars on basis of normal (1915) values.	National meaning of loss under present circumstances.		National gain from correct practice.
500,000,000 tons.	A small percentage of the energy	Energy	At least double the present recovery. (On basis of widespread utilization of gas in place of solid fuel, etc.)	$1,000,000,000 + in needless mining and transportation of coal.	Needless burden upon over-worked railways. Smoke nuisance in cities, entailing untold destruction of civic betterment attainments. High cost of coal to consumer. Resource waste.		Some relief to transportation. Complete elimination of smoke. Cheaper fuel.
		Nitrogen (ammonium sulphate).	5,000,000 tons. (On basis of 20 pounds per ton coal.)	$280,000,000	Serious nitrogen problem affecting field of fertilizers and explosives. Dependence upon Chile for sodium nitrate. Large expenditures for atmospheric-nitrogen plants. High cost of nitrogenous fertilizers, reflected in cost of food.	Inadequacy of coal-products industries. Problems in explosive manufacture.	Nitrogen independence, contributing to food production and explosive manufacture.
		Benzol	1,000,000,000 gallons. (On basis of 2 gallons per ton coal.)	$300,000,000	Undue dependence upon gasoline as motor fuel, contributing to overproduction and rapid exhaustion of the petroleum resource.		Contribution to supply of motor fuel. Advancement of good-roads movement. Establishment of large coal-products industry. Gains in new directions to be developed by chemical research.
		Tar	4,000,000,000 gallons. (On basis of 8 gallons per ton coal.)	$100,000,000 Additional value of coal-products manufactured from benzol & tar.	Neglect of roads.		
		Total....	....	$2,000,000,000	....	....	Capacity for relieving cost of living $10-$20 annually per capita. Gain to American industry.

Foot note by J. C. D.—Since the above table was prepared, changes in some of the market values have taken place, so that the authors, if constructing the table today, might use somewhat different figures. The overall teaching of the table is as substantially the same today as when drawn up. Some progress has been made along a few of the possibilities outlined.

of Pennsylvania, and a corner stone of its prosperity, is its great deposits of bituminous coal. Not so much the raw coal shipped from the state, but rather the coal utilized through the direction of engineering science in manufactures within the state, has made and will continue to make the state rich and prosperous. Great as has been the prosperity resulting from the varied uses of coal, science has still greater prosperity ahead for Pennsylvania through more complete and still better ways of getting the various riches of which raw bituminous coal is a storehouse or a source.

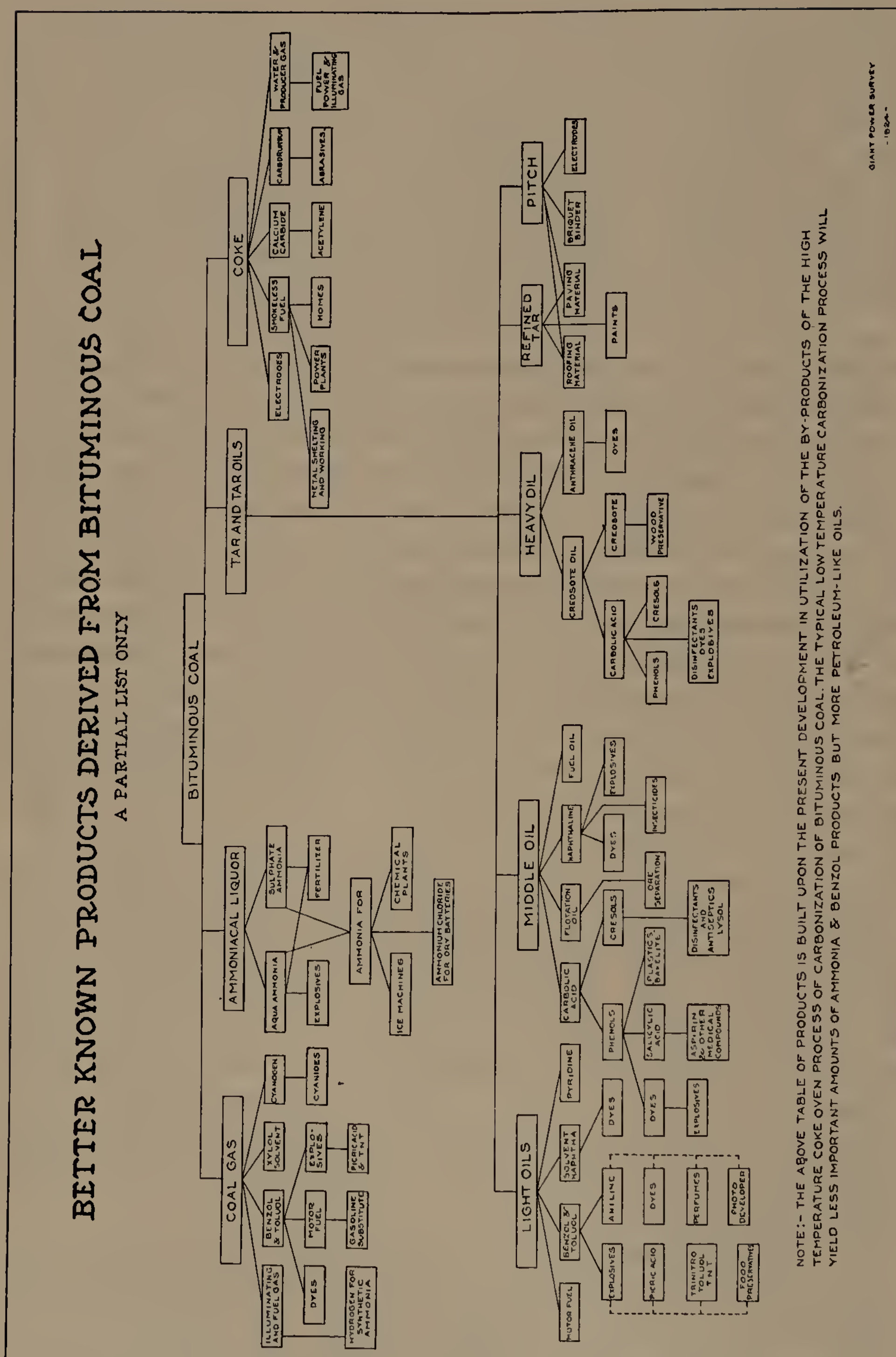
Bituminous coal thru distillation can be made the source of many useful materials. The United States imports yearly large amounts of creosote oils for preserving timber, (in 1922, 41,567,000 gals. valued at $4,240,449.00) while burning hundreds of millions of tons of raw bituminous coal, each ton of which would produce several gallons of creosote. The United States government experts declare that the nitrogen contents of our agricultural lands are being extracted so fast without sufficient restoration, that in ten years the production of our farms will be so far diminished that our standard of living must be reduced. Yet each ton of the nearly one-half billion tons of bituminous coal burned each year is accompanied by the destruction of what might have yielded several pounds of ammonia, a nitrogenous fertilizer.

Twenty-five years ago, nearly all of the coke used in the steel and allied industries of Pennsylvania and the United States was produced in the so-called "bee hive ovens" in which coals containing large percentages of constituents capable of making oils, ammonia, creosote, tars, illuminating and fuel gas, etc., were made into coke with a complete loss of these possible by-products and even with the combustion of some of the solid residues. To-day, in normal times, the bee hive oven cannot compete with the by-product coke oven plants from which these by-products are saved and utilized for other purposes. Not only do such ovens save for mankind's use these wonderful by-products from which he makes by the further application of science, explosives and dyes, perfumes and medicine, fertilizers and road building materials, preservatives and disinfectants, smokeless and efficient fuels in the form of gas, oils and coke, but the nuisance and damage to human health and to property occasioned by the clouds of smoke and vapors escaping from the old bee hive ovens are prevented, for now this "smoke" is too valuable to be allowed

to escape. It is true, about 30% of the total coke supply of the United States and more than half the coke produced in Pennsylvania is still produced in bee hive ovens, largely because they meet, under present conditions, the intermittent peak demands for coke or because demands in certain localities are less than warrant the building of the more expensive by-product ovens. By-producting to be efficient and economical must be a continuous process of rather large size whereas the bee hive oven is cheap to install and not seriously injured by intermittent use. However, practically no new bee hive ovens have been constructed in recent years and the number available for active service has continuously declined. In Pennsylvania there are now 17 high temperature by-product coke oven plants including the largest coke oven works in the world, that at Clairton, Pa., which is designed to ultimately coke 25,000 tons of coal each 24 hours. In the United States there are 75 coke oven by-product recovery plants capable of carbonizing nearly 70 million tons of bituminous coal a year. In 1923 the by-product coke ovens of the United States produced and sold or utilized by-products (not including coke) of the value of $112,075,945, (equal to $2.06 worth of by-products per ton of coal carbonized), while producing 37,597,664 tons of coke from 54,275,577 tons of coal. The year 1923 exceeded all records in the production of coke with by-products. The 34% increase in the amounts of by-products was absorbed at a slight increase in selling prices over those of 1922.

The data gathered by the U. S. Geological Survey indicates that the total values assigned to the products of by-product coke oven plants during recent years, has exceeded the value of the coal used by an average of over $2.00 per ton of coal charged into the ovens. In other words, in spite of the consumption of fuel in carbonizing, there was $6.00 worth of products for every $4.00 worth of coal charged into the oven. This is a measure of the combined operating costs and fixed charges of carrying on the operations. Since the number of plants is constantly increasing, this figure may be assumed to include a living profit.

Up to and including 1924, the many millions of pounds of coal consumed in the power plants of this State and of the nation have been burned raw, without attempt to recover those substances, whose value when separated from the coal, exceeds their value as raw coal heat units. The experience of many years has demonstrated that to



NOTE:- THE ABOVE TABLE OF PRODUCTS IS BUILT UPON THE PRESENT DEVELOPMENT IN UTILIZATION OF THE BY-PRODUCTS OF THE HIGH TEMPERATURE COKE OVEN PROCESS OF CARBONIZATION OF BITUMINOUS COAL. THE TYPICAL LOW TEMPERATURE CARBONIZATION PROCESS WILL YIELD LESS IMPORTANT AMOUNTS OF AMMONIA & BENZOL PRODUCTS BUT MORE PETROLEUM-LIKE OILS.

burn raw high volatile coals as efficiently as low volatile coal requires more expensive installations and greater skill. The market price of high volatile coals is usually 25 to 50 cents a ton less than that of low volatile coals of similar b. t. u. tests. This means, of course, that burning high volatile coals raw either results in a decided waste of important parts of the coal substance which escape to the atmosphere partly or wholly unburned, or else a considerably larger investment must be made to prevent this waste. The power industry has spent large sums of money and devoted great intelligence to solve the problem of obtaining and turning into steam the largest possible number of b. t. u.'s (heat units) produced by the combustion of raw coal, including, of course, those components which go to make the above mentioned valuable by-products. Science and the broad visioned individual may well ask the question, "Has not the power industry been barking up the wrong tree?" "Why has it not sought more values and therefore an ultimately cheaper source of fuel for power production by extracting from the raw coal its greater potential values, rather than crudely destroying them and trying to utilize the final and most elemental product of that destruction?"

Men of vision and science have noted this apparent short-coming and have been working on methods to remove it. Four groups of developers have acknowledged spending nearly $25,000,000 in the past ten years, nearly $15,000,000 of which has been spent by two prominent American groups. Methods known under the terms of "Low Temperature Distillation or Carbonization" and "Gasification with recovery of by-products" have been so far advanced that some large users of bituminous coal for power and heat have already installed plants designed to handle hundreds and thousands of tons of coal a day. Beside the Ford Motor Company's recovery plants at Windsor, Canada and River Rouge, Michigan, and others mentioned above, in England, the Mond gas producer has been improved so that Low Temperature oils as well as large yields of ammonia are recovered. In Washington, Pa., the Combustion Utilities Corporation has in operation a large gas producer recovering large amounts of by-product oils and providing a richer gas to a glass factory at less net cost than by the older methods operating without recovery. In Germany, many chemical plants have been treating their coal for by-products to be used in chemical manufacture while developing their power requirements from the least valuable combustible residues.

In Pennsylvania, the home of richly volatile bituminous coals, so far as the Survey has been able to learn, up to 1924, scarcely a cent had been spent by the large power interests to develop and apply the possible economy of pretreatment of its bituminous fuel. Possibly this inertia in the private industry has been in part because of a dislike to add to management the function of producing and marketing products other than power, in part because of a distrust of the ability of an apparently controlled market for tar and other by-products to absorb at fair prices its yield of by-products. It is commonly recognized that there is virtually only one purchaser for crude by-products in the United States. Very probably, in the relatively small power plants operating in the state, (the average of the twelve largest plants being about 80,000 kw.) marketing independently, would involve extra expense and skill which would not be warranted. But with very large stations, these objections lose force. After all it is only the market for the heavier tars which may be restricted since the market for the other products, such as light oils, for gasoline engines, ammonium sulphate, gas and fuel oils, are expanding so fast as to be practically unlimited.

Happily the latest information is that a beginning is about to be made in this industry in Pennsylvania. When the initiative and enterprise of the power people of Pennsylvania are definitely devoted to this problem of pretreatment of fuel designed for power production, we shall see another worth-while step in the production of cheaper power and in the supplement of our supplies of fuel for automobiles and other internal combustion engines and of raw materials for numerous chemical industries.

According to the particular circumstances involved in each case, a choice may be made of one or more of several processes, some of which are already proved commercially feasible, while others have reached the stage of successful demonstration in large scale experiments. High Temperature Distillation operating at temperatures between 1700° and 2000° Fah. in by-product coke ovens will continue to produce coke for metallurgical purposes, and gas for fuel purposes as an important by-product, together with ammonia and tars which are the basis of the present so-called "coal tar industries" producing dyes, explosives, perfumes, medicinal compounds, etc. The complete gasification processes, with recovery of low temperature tar

oils and ammonia, will provide gaseous fuels for nearby industrial and possibly domestic users.

The Low Temperature Distillation or Carbonization processes, operating at temperatures between 900° and 1300° Fah. will yield large amounts of oils and tar acids, gasoline substitutes, lubricating oils, disinfectants and preservative oils, some rich gas, and a smokeless, yet easily kindled solid fuel for power and heating plants, domestic purposes, and for locomotive fuel. The carbonized solid residue or semi-coke as produced in some of the low temperature processes will make an excellent powdered fuel or may be ground with tar or petroleum oils to make a semi-liquid emulsified fuel, usable in oil-burning equipment.

The low temperature processes are looked upon as likely to be the more economical compared to the high temperature processes, for pretreating bituminous coal, for the following reasons. Operating at a lower temperature than the high temperature processes, less fuel will be consumed about the retorts in order to maintain the proper carbonizing temperature; less heat will be lost in the condensing system because of the lower temperature of the various products evolved; the original cost and the maintenance of furnaces and retorts will be less; and the sizes of pipes, tanks, etc. required in handling the volatilized products will be smaller. The oils recovered will be in volume two or three times larger and of distinctly greater value per gallon, than the high temperature tars.

With production of large volumes of combustible gases, the possibilities of piping this gas under high pressure into communities too small to justify the construction of a local gas plant, loom up. Even our larger cities may find it possible and economical to obtain a large part of their gas supply from power plants or commercial smokeless fuel producing stations in or near the coal fields. Recent studies of the possibilities of supplying the city of Buffalo, N. Y. with coal gas from the mines 125 miles distant in Pennsylvania put the cost of moving the gas, including capital allowances, at approximately 5c per thousand cu. ft. With still larger volumes, and in combination with Giant Power electric transmission line rights of way and using electric gas compressors operated in connection with Giant Power substations, it is probable that gas could be moved 300 miles within a cost of 10c per thousand cu. ft.

In the western part of the state, about 135 billion cubic feet of

natural gas are annually distributed and sold. Of this about 40 billion cu. ft. are piped in from adjoining states. With the progressing decline in the production of natural gas, the existing natural gas systems will be eager buyers of coal gas from giant power fuel treatment plants. See Appendix C (IX). In the rest of the state about 30 billion cubic feet of manufactured gas, made in part from bituminous coal, in part from high priced anthracite, coke, and oil, are distributed and sold—nearly 25 billion cubic feet of this are distributed within 40 miles of Philadelphia.

In prosperous years, upwards of 75 million tons of bituminous coal are burned in Pennsylvania, in dull years around 50 million tons. Of the total bituminous coal deposits of the state, the State Geologist estimates that 83% are of qualities which will yield 25% or more as volatile matter and 65% of the total deposits will yield 35% or over on a moisture and ash free basis. With nearly 44 billion tons of bituminous coal in the mines of the state, there is plenty of high grade material to supply pretreatment processes for many generations, to contribute to the permanency of the oil supply as well as to chemical manufacture.

From this 50 million tons of bituminous coal yearly burned raw in Pennsylvania there could be obtained by the High Temperature process 35 million tons of coke; 300 billion cu. ft. of gas (nearly double the present combined sales of natural and manufactured gas); over 100 million gallons of light oil, suitable for use in internal combustion engines or enough to run each of Pennsylvania's 1,000,000 licensed automobiles 1,000 to 1,500 miles; 500,000 tons of ammonia sulphate, enough to restore the deficiency in nitrogen of 8⅓ million average cultivated acres which is about one-half of the improved lands of Pennsylvania; and 400,000,000 gallons of tax and pitch. At recent average selling prices, the value of the various by-products would be over $100,000,000 a year. This volume of by-products would about equal the actual volume of products obtained in the year 1923 from the 54 million tons of coal charged into by-products ovens in the United States.

In the strictly Low Temperature Distillation process of treating bituminous coal, there is but little recovery of ammonia but much larger yields of oils—together with much less but richer gas. If the 50,000,000 tons of coal referred to above were subjected to a typical Low Temperature Distillation there would result 38 to 40 million

tons of a really smokeless but easily kindled fuel suitable for boiler fuel; the lumpy portions of it for domestic fuel, or if ground and briquetted, as a desirable substitute for anthracite coal; 250,000,000 gallons of gasoline oils; 250,000,000 gallons of creosoting and disinfecting oils; 500,000,000 gallons of tar oils suitable for fuel oil and as base for chemical industry; and from 75 to 100 billion cu. ft. of rich gas. At reasonable market values these products, including about 100 billion cu. ft. of gas, but excluding the smokeless solid fuel, would be worth close to $100,000,000 a year.

In order to take advantage of all economies and provide cheap power, as well as a liberal supply of gasoline and fuel oils, creosotes and tars, and prepared smokeless fuel at prices to encourage its broad use, it is necessary to coordinate all functions pertaining to fuels beginning in the mine and continuing thru sorting, by-processing, power generation, and preparation for the market of the several resulting fuel supplies and materials for chemical industries. Such a program provides for the elimination of much of the waste incident to our one idea in mining and the separate one idea in power production, but requires that the business be conducted in very large units, say handling 25,000 tons of coal per day and located at the most favorable points which naturally are at or near the mouth of the mine.

Under such conditions, the High Temperature Distillation process can be expected to operate so that the resulting coke, after sale of by-products, will cost a little more than the equivalent raw coal from which it is made. As a means solely to provide a treated fuel for a power plant, it is probably as at present operated, not now economically feasible. One must note, however, that the by-product coke oven has been developed with the one dominant idea of producing a coke suitable for metallurgical work. Such by-product coke is in competition only with non-recovery bee hive oven coke which necessarily has to sell at a marked advance over the cost of raw coal. Practically no consideration has been given to adapting the process to power plant needs, where the physical and chemical qualities of the coke would be of minor importance, but where the competition would be with raw coal as a fuel. Yet some engineers largely experienced in the high temperature processes apparently believe that the by-product oven process might be modified so as to produce power plant fuel to compete with raw coal and would welcome a real

opportunity for development in that direction. Since there is a definite market for a considerable tonnage of first class coke at prices representing $2.00 to $3.00 a ton above raw coal, by selecting the saleable parts of the product for market and burning in the power plant the less valuable portions of the coke a power plant fuel would become available at a real saving over the cost of raw coal.

In the Low Temperature Distillation processes, a consideration of the development of at least one successful process now operating in the United States leads to the deduction that it can be applied on a large scale solely as a part of a Giant Power plant, with a probable present saving in the cost of fuel of 75 cents per ton,* and as the market expands for the by-products, it may see a still greater saving. In combination, as a great fuel mining, recovery, utilizing, and selling agency, the calculations given at the end of this report, with the assumptions there made, would indicate the possibility of obtaining residual fuel for the power plant at a mere nominal cost, provided all the profits above fixed charges arising from the combination coal handling and treating were considered as reducing the cost of the residual fuel. That the cost could be reduced by $1.00 to $1.50 per ton appears probable, under a reasonably equitable distribution of savings.

Our advancing civilization calls for larger and larger volumes of controllable energy in the two fundamental forms of heat and power. We have long passed the state where human and animal muscular power can meet the demand for energy. Except for a few especially favored districts, we have outgrown the possible supplies of energy from water power. We are positively and majorly dependent upon the deposits in the earth of fuels—natural gas, petroleum, and coal in its numerous forms. In less than one generation, it is estimated that the available supplies of natural gas and oil will be so depleted or probably so nearly exhausted that they cannot contribute materially to the demand for energy. Even now with large amounts of natural gas and oil being withdrawn from the all too small deposits in the earth, less than 15% of the energy requirements of the United States are being met from these natural resources. Our mainstay then, rests with our coal deposits, enormous but not inexhaustible.

Our diversified demands for energy are now met from the four

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* See appendix No. C IX.

sources of solid fuel, gaseous fuel, oil fuel, and water power. The indications of the future are of increasing demands for power as electricity in very large volume, widely distributed to even small units of use; gaseous fuels for the lesser heating requirements; oil fuels for mobile power as in automobiles, tractors, launches, ships, and those few places which, because of isolation, it is not feasible to reach with electric power; and probably a relatively diminishing demand for solid fuel, except at important centers of large consumption, such as Giant Power electric stations, gasification and smokeless fuel preparation plants, large industries like steel plants, and the winter heating requirements of buildings. Such solid fuel as is required will be wanted as truly smokeless.

As has been indicated above, the proper treatment of bituminous coal will provide all or very important portions of the requirements for each form of energy. By concentrating the preparation of the fuels at the mines and the development of power thereat, economies in material, labor, and capital can be developed which will meet the other overall requirement of an advancing civilization, which is that its natural resources shall be conserved, yet made available at the lowest possible costs.

The Claude Process for manufacturing ammonia synthetically from gaseous nitrogen and hydrogen is an example of the allied industries which might be expected to locate close to such giant coal treating and power stations. This is a process being installed on a large scale in France and England and soon to be installed in the United States. This process utilizes coal gas as its cheapest source of hydrogen. In the separation of hydrogen from the coal gas and also in the separation of nitrogen from the air, large amounts of cheap electric power are required to operate the powerful, high pressure compressors. Per ton of anhydrous ammonia produced, using hydrogen from coal gas, 3,271 kw. hours are required. Such an industry would fit in most economically where both gas and power would be available in large quantities at the lowest costs, as would be the case at our contemplated Giant Power stations.

Because its prosperity is so dependent on its bituminous coal resources and because this resource is being exhausted at a relatively faster rate than the coal fields of other states, Pennsylvania particularly needs to be a pioneer in taking steps to rapidly bring about an efficient, concerted conservation and most efficient use of this

resource. This involves the pretreatment of the coal with recovery of all possible values from the coal, furnishing efficient, economical, clean, smokeless, fuel in the forms of gas or carbonized fuel, and associated with the production of cheap electric power, made largely from the wastes occasioned or existing under present day methods of handling our fuel resources.

By-producting or gasification by any method is accompanied by the consumption and loss of from 10% to 15% and in some cases over 20% of the total potential heat energy in the original coal. This loss, however, will be more than made up by the greater efficiency in use of the various products. The gas and oil derived will give from 2 to 10 times as much useful work and effects as those possible to obtain directly from the equivalent weight of raw coal. A comprehensive and intelligent substitution of smokeless solid or emulsified fuel and by-product oils and gases together with Giant Power electricity would save so much of the waste occasioned by the use of raw coal in homes and factories and in power generation in relatively small power plants, that there would be a final net saving in the total fuel mined to meet present requirements. General coal carbonization therefore is a real conservation.

In the light of recent inventions and investigations, the greatest conservation and maximum usefulness of our bituminous coal resources must come about with the following coordinated accomplishments:

(1) Bring to the mine mouth a far larger percentage of the combustible present in the seams encountered in the mine than now.

(2) Sort, screen, or wash at or near the mine mouth the mined coal to purify, and prepare for

(3) Shipment raw only to such industries as large steel plants, and large gasification works which can to advantage by-product their coal supplies.

(4) Carbonization at or near the mine by High Temperature ovens, to supply the demand of blast furnaces, foundries, etc. which can not well operate recovery plants yet need metallurgical coke.

(5) Carbonization at or near the mine by Low Temperature processes. The product to be powdered and sold ready for dust firing, both for power and all heating processes except in smaller furnaces and stoves. For these, naturally formed lumps of the Low Temperature coke, or briquettes made from the fine material would be prepared for sale. Only limited amounts of this solid fuel

would be required, since in the larger communities much of the smaller demands for heat would be met by gas, and large consumers would use powdered fuel.

(6) Production of electric power in large volume by burning the "breeze" and other low grade fuel material or surplus by-products; transmitted at high voltage across the state, using rights-of-way jointly with gas transmission mains, and possibly powdered emulsified coal mains.

(7) Production and transmission of fuel gas as a result of carbonization to be distributed in small hamlets along and near the transmission pipe lines as well as in large cities for general heating purposes.

(8) Production of motor gasoline and Diesel engine oil fuel from the oil tar by-products for automobiles, ships, and isolated or temporary power purposes where the extension of electric service is impracticable.

(9) Production of ammonium compounds and of chemical base materials from the tars and liquors.

(10) Associated chemical and electro-chemical industries requiring cheap power, coke, gas, and other by-products, such as, the Claude Process for making ammonia, calcium carbide process, roofing and road materials, etc.

(11) The preparation of emulsified coal fuel to be transported in tank cars or possibly by pipe lines, and to be used in oil burners for large and small heating plant purposes.

As a picture of what such a program means in relation to a Giant Power Station, requiring each 24 hours the heat equivalent of 5,000 tons of high grade coal of about 14,000 B. T. U. per lb., we may make for a general case certain assumptions and calculations.

(1) Raise from the mines daily 20,000 net tons of coal material, which will sort to

(2) 15% or 3,000 tons hard bone coal, useable in by-product gas producers.

15% or 3,000 tons soft bone and coal dirt, to be burned raw.

20% or 4,000 tons good coal for high temperature ovens.

45% or 9,000 tons medium good coal for low temperature ovens.

5% or 1,000 tons specially selected coal, i. e., sized lumps for sale.

(3) The above will provide for the power plant

3,000 tons low grade raw coal @ say 9,000 B. T. U. per lb.

290 tons high temperature coke breeze and refuse @ 12,000 B. T. U. per lb.

3,375 tons low temperature fine coke residues @ 12,000 B. T. U. per lb.

6,665 tons which will yield the equivalent in heating value of 5,000 tons good grade raw coal.

(4) The yields of saleable material will be:

High temperature lump coke 2590 tons @ $4.00	$10,360
Low temperature lump coke 3375 tons @ $3.00	10,125
Gas for city and town distribution 82 million cu. ft. @ 20c. M. cu. ft.	16,400
Motor gasoline substitute oils 56,000 gals. @ 15c.	8,400
Ammonia sulphate 220,000 lbs. @ 2½c.	5,500
Tar oils and tar acids 300,000 gals. @ 4c.	12,000
Selected coal sold 1,000 tons @ $3.00	3,000
Total credits, sales	$65,785

(5) The costs of operation:

14,000 tons r. o. m. coal @ $2.00	$28,000
6,000 tons bone and refuse coal @ $1.00	6,000
13,000 tons of coal processed—oper. costs @ $1.55 ton	20,150
Investment charges @ 70c. per ton	9,100
Sorting and separating raw coal, and miscellaneous other handling charges not covered by above, 20,000 tons @ 10c.	2,000
Expenses of merchandizing @ 1% of selling values ..	658
	$65,908

There remains the fuel required for the power plant at practically no cost since the returns on the fuel and by-products sold practically balance the total costs of operation and investment charges connected with handling and treating the 20,000 tons of coal.

In the above calculations, assumptions not shown by the tabulations have been:

(a) Thermal efficiencies of combustion taken at 80%.

(b) Bone coal in producers considered as $8,000 B. T. U. per lb. and gas produced at thermal efficiency of 60%. All the producer gas, after recovery of by-products, used to heat the retorts.

(c) The investment costs of the low temperature and high temperature plants, including by-product recovery equipment as usually installed and the producer gas plants are taken at a common figure of $1,600 per ton coal charged daily capacity, it being anticipated that the low temperature equipment should cost considerably less than the high temperature.

(d) The low temperature process contemplated is of the horizontal cylinder type, with agitation, producing part of the product in fairly coherent lumps suitable for sale as domestic fuel, and easily kindled, smokeless coke. It is priced somewhat lower than high temperature coke, so that it may reach a broader market, to aid in reducing the smoke nuisance.

(e) The oven gas produced is assumed sold at the works under contract to the existing natural gas distributing companies. The price of 20 cents per M. at points within 50 miles of Pittsburgh appears reasonable compared with West Virginia natural gas at 35 cents at the Southern state line of Pennsylvania.

(f) The total investment except land between the mine mouth and the equivalent machinery required to put raw coal in the boiler plant, necessary to handle 20,000 tons mixed quality coal as outlined, is of the order of $20,000,000, against the electric power plant of 500,000 kw. capacity, fully equipped with its necessary fuel handling machinery which is approximately $37,500,000.

(g) Such a scheme would permit of the gradual introduction of the various types of coal treating equipment as developments warranted. The high temperature coke ovens could go in early, and probably the by-product producers, the low temperature system later though its adoption is essential to the success of this scheme, both from standpoint of cheap power, and of furnishing the public with a reasonably priced smokeless fuel.

(h) At any time excess gas or tar were available unsold, they should be used at the power plant but their use there would have the

effect of increasing the cost of fuel and plans should cover the disposal of the entire output.

(i) Fixed charges are based upon prudent investment and a rate of return allowed regulated public utilities.

Technical Report No. 5

RURAL ELECTRIFICATION

By George H. Morse

When farmers in Pennsylvania wake up to the fact that electricity can transform their lives from drudgery and ineffectiveness to comfort and accomplishment nothing will prevent them from having it.

There is no insurmountable obstacle in the way; a will for electric power will bring it. Mr. Samuel Insul, who controls electric properties approximating $650,000,000 in value has recently said: "Regarding rural service, it is bound to come and in the comparatively near future. The farmer is entitled to it and he will get it."

The character and distribution of available farm power in Pennsylvania during the year 1920, other than from human muscles is given in Table I.

TABLE I.

Available Farm Power in Pennsylvania in 1920

Type of Power	No. in use, or installations		H. P. per Unit	Total H. P.	% of Total
Farm automobiles..	86,750	97,000	20	1,940,000	67.6
Farm trucks	10,250				
Tractors	6,823		15	102,345	3.6
Gas Engines	54,500		2.5	136,250	4.7
Windmills	31,400		1	31,400	1.
Horses and Mules ..	561,047		1	561,047	19.6
Elec. Cent'l Station	12,452		2.5	31,100	1.1
Elec.—Individual Plants	11,132		6	66,792	2.3
				2,868,934	100.0%

George H. Morse graduated in electrical engineering at the University of Minnesota and took the "Course" at the Schenectady works of the General Electric Company. Twelve years factory experience with the Wagner Electric Manufacturing Company, Mutual Electric and Machine Company, and National Metal Molding Company was in part followed by twelve years in charge of the Department of Electrical Engineering at the University of Nebraska, and four years as a power specialist with the U. S. Emergency Fleet Corporation.

Mr. Morse is a Fellow of the American Institute of Electrical Engineers and is attached to the Pennsylvania Public Service Commission and the Giant Power Survey as an electrical engineer. He has done considerable consulting engineering work in the design, construction, operation and appraisal of electric railway and other electric properties.

The accompanying curve, Figure 1, shows the growth of such power since the year named. Two things are clearly apparent from the figures contained in the above table. One is that the farmers are rapidly awaking to the advantages offered through the application of mechanical power other than that afforded by the muscles of men and animals. The other thing is that upwards of eleven thousand

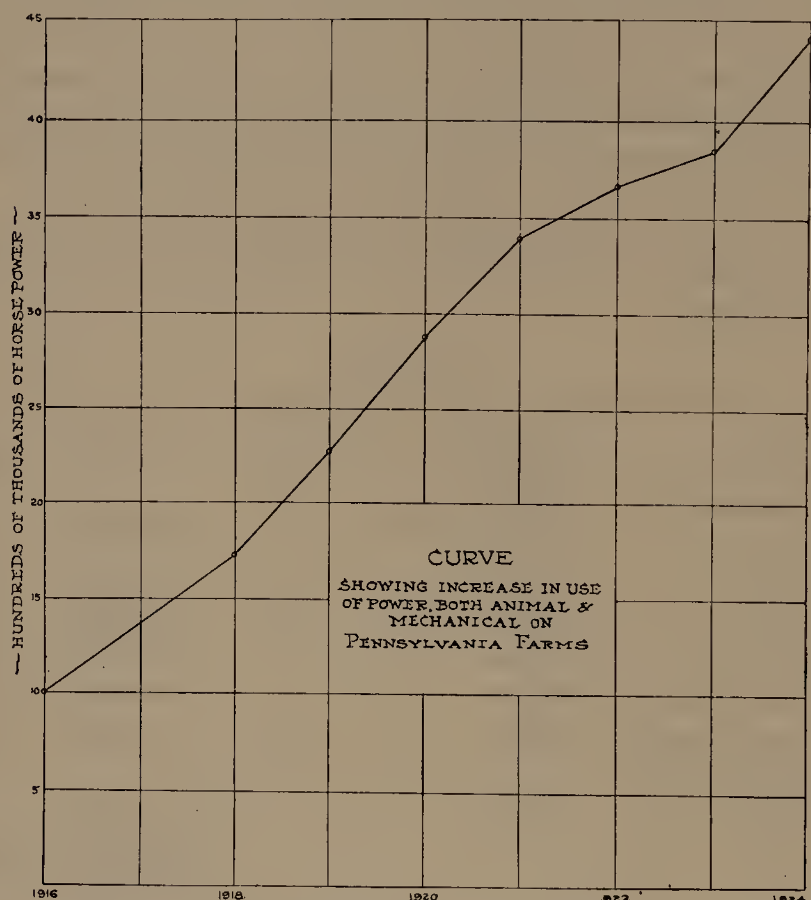

FIG. 1. RECENT GROWTH IN POWER USED IN PENNSYLVANIA AGRICULTURE

Pennsylvania farmers are finding electric power so desirable that they have been willing to invest from five hundred to a thousand dollars each for individual plants from which they obtain electric energy at a cost of approximately thirty-five cents per kilowatt hour. There are on file with the Public Service Commission at Harrisburg, only seventeen strictly rural rates for electric service. The effect

of these seventeen rates is to cause the average cost per kilowatt hour, for 50 kilowatt hours per month, to be 14 cents, and for 100 kilowatt hours 11.6 cents. When, in this connection, we consider that the twelve thousand or more farms in the State, which are receiving electric energy from central stations, are paying a high figure compared with what farmers are paying in certain other localities outside the state, it becomes clear that there would be both a vast demand and great opportunity for the extension of central station service to farms within the state at more moderate rates.

There is perhaps no better example of the use which farmers make of electric energy when they can obtain it at reasonable cost than is to be found in Waukesha County in the State of Wisconsin. In that County more than two hundred farms are attached to rural lines of the Milwaukee Electric Railway and Light Company and its associate, the Wisconsin Gas and Electric Company. Over ninety per cent of the electric energy generated in and about Milwaukee is from steam power, less than ten per cent coming from a hydro-electric plant at Kilbourn on the Wisconsin River. Rates for rural service in Waukesha County established in October, 1920, are still in effect and are deemed satisfactory both by the company and its consumers. The physical details of their farms covering areas and stock carried will be found in Table I, Appendix B-IV Studies in Rural Electrification.

Eighty-two of the Waukesha rural consumers who replied to questionnaires sent out by the Giant Power Survey were found to be using electric appliances as set forth in Table II, of the Appendix B-IV.

Note the liberal use made of electric ranges, nearly half of the consumers replying to questionnaires having them. Coal from the Illinois fields or from the east by way of the Great Lakes is not hard to obtain in Waukesha County. The farmers have simply found electric ranges, at the prices paid for current, to be economical and desirable. Many adopt them in order to keep the kitchen cool in summer.

A report of the monthly operation of ninety-five electric ranges in five small towns and their rural environs in Iowa is published in the *Electrical World,* August 9, 1924. The families using these ranges run in size from two to eight persons. The number of persons in the family appears to have but little influence on the quantity of

electric energy consumed by the electric range. The ranges vary in size from 2000 to 6000 watts the average being 5034 watts. The largest consumption of energy in a month by one range was 210 kilowatt hours; the next largest 190; the smallest 24, and the next smallest 30. The average monthly consumption was 82 kilowatt hours, and the average cost per kilowatt hour 5.1 cents. The average number of persons in the family was 3.4.

As to the cost of current on the Waukesha rural lines, the average monthly bill of 215 rural consumers for the winter months of 1923 is $7.91 and the corresponding consumption of energy 167 kilowatt hours.

The average monthly bill of 234 consumers for the spring months of 1924 is $7.83 and the energy 147.66 kilowatt hours.

The average cost to a consumer per kilowatt hour based on all accounts is for winter 4.7 cents, and for spring 5.3 cents. With the three largest consumers not counted the figures are 5.2 cents per kilowatt hour for winter and 6.1 cents per kilowatt hour for spring.

Nearly all of the common household and farm electrical appliances are represented. The list of uses names twenty electric lighted chicken houses. The lighting of chicken houses to induce a greater production of eggs in winter is becoming quite general where electricity is available from central stations. It is confidently stated by those who have experimented with the system that 20 per cent more eggs can be obtained in winter by this means and that an increase even as high as 41 per cent has been observed. The proper allowance for electric energy is said to be 2.5 kilowatt hours per day for 1000 hens.

Other uses for electricity on the farm are the following:

IN THE HOUSE

Centrifugal clothes dryer.

Motor for beating up batter and whipping cream and eggs.

Open grate for room warming.

Air heater. Can be used with blast fan for drying face and hands to save towels. It is also more sanitary than towels.

Portable hair dryer; contains small fan and heater to produce hot blast.

Immersion heater, useful to heat shaving water or baby's milk.

Foot warmer; for bed or floor use. Such a device was used on

board submarine chasers during the war to keep the helmsman's feet warm.

Humidifiers; badly needed for preserving health in winter when heating the house by means of hot air furnace.

Ozonator; brings sea air to the sick room.

Adding machine. It is hard to believe but a number of farmers on the Minidoka Project, an irrigated area in Idaho run by the Government, report the use of electrically driven adding machines on their farms. Whether they are over prosperous or merely poor at figures we do not know.

Siren. Takes the place of the dinner bell, on some ranches; might be useful on large farms.

In the Hennery

Incubator.

Hover for chicks.

Egg tester.

Electric lamp under water trough in winter to keep water from freezing.

In the Dairy

Churn.

Milk cooling pump.

Milk tester, Babcock or other

Milk can dryer.

Pasteurizer.

Stirring equipment for cheese vat.

Ice cream freezer.

Ice breaker.

In the Farmyard, Shops, Stable and Barn, Field and Orchard

Fruit press; used for grapes and other juicy fruits.

Cider press, screw type.

Cider mill, continuous action.

Dehydrator for drying pomace. The apple pulp, after pressing for cider, which is called pomace, contains a valuable store of pectin used with fruit juice to induce jellification.

Centrifugal extractor for honey.

Sausage stuffer.

Pruning apparatus.

Prune and plumb harvesters (Picks fruit up from ground).
Root washer.
Fruit pulper.
Wood splitter.
Circular saw.
Drag saw.
Grinder and buffer.
Lathe.
Grindstone
Forge blower.
Concrete mixer.
Groomer.
Soldering Iron.

THRESHING BY ELECTRICITY

Large portable motor and transformers; abroad, notably in Sweden and Germany, a motor large enough to drive a threshing machine is mounted, together with transformers, in a covered wagon. This equipment is passed about from farm to farm for use in threshing and silo filling. Threshing machines vary considerably in the quantity of power which they require according to the volume of grain they are capable of treating in a given period of time. There appears to be considerable reason for believing, however, that most threshing machines, as at present constructed, have unnecessary power consuming refinements. As evidence of this, *Agricultural Engineering* for March, 1924, gives an account of a small experimental threshing machine built and tested by students at the University of California. This machine requires less than 1½ horsepower to drive it. On test 1500 bundles of grain were threshed at a rate which kept two men busy feeding the bundles and removing the grain and straw while a third man was engaged in keeping the record of operations. The grain is said to have been as clean as that obtained from a large, highly developed, threshing machine. A stationary threshing machine which requires 2 to 3 horsepower and is capable of threshing 25 to 35 bushels of wheat or 40 to 50 bushels of oats per hour is to be found in the market. The machine is stated to be "large enough for 150 acre farm. Is what every farmer needs who desires to do his own threshing at his convenience with his own help." The use of machines requiring as little power as possible to operate them is of vital importance in

keeping the rates for service down. The extra investment in electrical equipment, both in lines and transformer capacity, which has to be provided to meet the demand for power of the largest types of threshing machine is considerable, and rates therefore will be unnecessarily high to meet the fixed charges on such an investment. About 4 bushels of wheat or 7 of oats can be threshed per kilowatt hour.

ELECTRICAL PLOWS

The use of plows drawn by cable is not new. The Spreckles Sugar Refining Company made a practice for years of plowing their sugar beet fields in California by means of heavy plows drawn back and forth by cables from a pair of large tractor engines disposed on either side of the field. These engines were of English make and repair parts were obtained from England. The company had decided to substitute electric motors for this service when the change was interrupted by the breaking out of the World War. Plows driven by electric motors mounted upon them are used in both Germany and Sweden. Various methods are employed to deliver current to these motors by means of trailing cables or such as are wound upon reels either mounted on the plow or at a fixed point from which the cable pays in and out over a swiveling sheave. Other systems employ trolley wires stretched over the field.

A manless plow, which was constructed at Iowa State College at Ames, Iowa,[1] is shown in Figure 2. This machine is run by a four horsepower gasoline engine but would be easily adapted to operation by an electric motor.

Quoting from paper by Prof. J. B. Davidson, "In operation the outfit is steered by hand for an initial furrow, after which the initial furrow serves as a means of guiding the plow, ..."

"The machine travels back and forth across the field in shuttle style. A reversing arm or antenna hangs over the tractor, extending out some distance beyond the machine in each direction. This reversing arm upon coming in contact with a fence or other obstruction is pushed back to a point where spring action comes into play and reverses the direction of the drivers. The reaction immediately lifts

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[1]Experimental study by Darrell B. Lucas, a student, with the assistance of E. V. Collins and Prof. J. B. Davidson.

FIG. 2 MANLESS PLOW

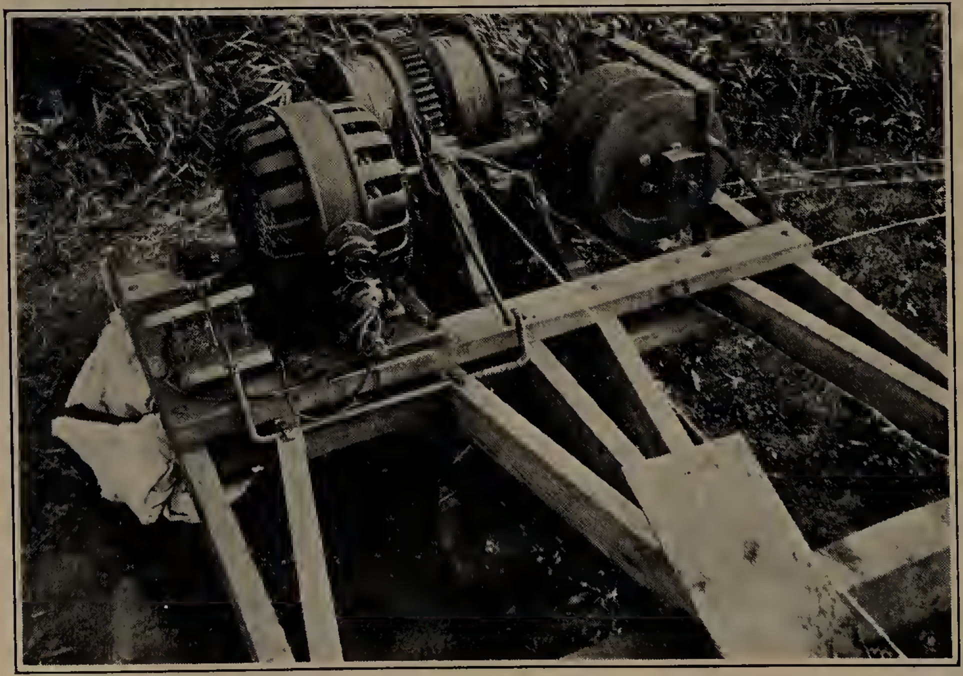

FIG. 3. ELECTRICALLY DRIVEN CABLE PLOWING EQUIPMENT

the plow in service out of the ground and swings the opposite plow down ready to enter the soil. This action takes place quite smoothly and positively.''

Effective means were devised to keep this plow in its furrow until an obstruction is reached when it reverses as above described, moves over the width of a furrow and then runs parallel with the first furrow being guided by it.

Prof. Davidson also described mechanism shown in Figure 3. This is an electrically driven cable plowing equipment built at Iowa State College.[1] Like the manless plow described in connection with Fig. 2, this mechanism is adapted for plowing a rectangular field. The plow is pulled back and forth across the field by the motor and larger cable drums, shown in Fig. 3 through cooperation with a pulley mounted on a skid on the opposite side of the field. The two small drums on the right in Fig 3 revolve slightly when the plow reaches either end of a furrow. This causes the whole power skid to move laterally a sufficient distance to properly place the plow for the succeeding furrow. All of these actions are automatic and take place without manual assistance once the machinery has been placed and the motor started.

A rotary tiller is replacing the tractor type of plow in Germany. Motor, reel, locomotive mechanism and the revolving earth cutters are all mounted together on one set of wheels, current being delivered to the motors by means of a trailing cable which passes over a sheave mounted high on a long bracket which projects far out from the left side of the machine. The largest type of rotary tillers requires 30 horsepower to operate it while the smallest type uses 4 horsepower.

In general, plowing with a plow driven by an electric motor requires a consumption of about 17 kwh. per acre. At six cents per kilowatt hour the cost per acre for electric energy will therefore be about one dollar.

Other Farm Machinery Suited to Electric Operation

Clover Huller.

Fanning mill for cleaning grain.

Seed cleaner and grader.

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[1]Experimental study by Edward D. Gordon, a student, with the assistance of E. V. Collins and Prof. J. B. Davidson.

Grain chopper; used for cutting hay, alfalfa or clover before blowing it into the mow.

Fodder cutter.

Silo filler: A suitable size driven by a 15 horsepower electric motor will handle 8 to 12 tons per hour. The energy required per ton is about 2 kilowatt hours when the stalks are cut into pieces ¾ inches long and elevated 40 feet into the silo.

Hay baler.

Corn sheller.

Corn cracker.

Corn and cob crusher.

Oyster shell crusher.

Oat crusher.

Rolling mill for oats.

Poultry feed mixer.

Stock feed mixer.

Fertilizer mixer.

Spray mixer.

Bone grinder.

REFRIGERATORS

The Waukesha list names four electric refrigerators. This is a device that is rapidly coming into use. There is a notable example of the application of electric refrigerator at the farm of Mr. J. A. Cochran about half a mile southeast of Mechanicsburg, Pennsylvania. Mr. Cochran has thermally insulated the building in which he stores his apples. By means of an electric driven refrigerating machine he is able to keep this storage house at the proper temperature, between freezing and normal outside temperature, at which apples keep most perfectly.

The anxiety of seven hundred ice manufacturers attending their national convention at Chicago to do away with what they termed the cheap "ice eater" used by the home, taken in the light of their committee's report that there are 10,000,000 homes in the United States supplied with electric current and 50,000 electrically driven household refrigerating machines already in use with 30,000 to be added during the current year, speaks volumes for the popularity of the power cooled refrigerator and ultimate extinction of the ice man. A household refrigerator of moderate size will consume in the

neighborhood of 50 kilowatt hours per month which at six cents per kilowatt hour will amount to $3.00. This is little more than the cost of an equivalent quantity of ice in many localities.

Hay Drying

Much successful experimental work has been done both in England and the United States on the drying of hay. In England the hay is spread over a long perforated wooden box, air being drawn into the box by an electric fan and expelled through the perforations. Rapid drying, preservation of the green color and flavor, keeping qualities, and food value of the hay are said to be greatly improved. In the United States a well known engineer[1] has applied hot air blasts to the same purpose. After a series of conflagrations he now claims to have developed a system whereby, with the use of 500 pounds of coal he is able to safely dry a ton of alfalfa in such manner that the leaves remain attached to the stalk thus conserving material that is otherwise wasted when natural drying is employed.

Drying of Vegetables

Mr. A. M. Hess of the Keewadin Farm at Shiremanstown, Pennsylvania, has carried the art of drying and mixing of vegetable compounds to a high degree of perfection. Figure 4 is a side view of the

Fig. 4. Exterior of Dehydration Plant at Keewadin Farm

[1]Experiments of Arthur J. Mason.

plant which was used to dehydrate 60,000 pounds of corn in 1920. Two fans, each with its driving motor, are visible in the picture. These fans draw heated air from three furnaces in the basement through sheet-iron drying ovens the fronts of which are to be seen in Fig. 5, which discloses another fan and motor and two women operatives preparing celery for drying. Fifteen to eighteen kinds of vegetables are dried, each requiring a different technique. These vegetables are then cut up fine by machinery and mixed to produce the makings of a soup which are shipped dry in packages.

FIG. 5. INTERIOR OF DEHYDRATION PLANT AT KEEWADIN FARM

VENTILATION OF DAIRY BARNS

Figure 6 is a picture of one of four exhaust fans (at center of picture), which are installed in the walls of the dairy barns at the Carnation Milk Farms, in Waukesha County, Wisconsin.

PROBABLE USE OF ELECTRICITY ON VARIOUS KINDS OF FARMS

Table III, Appendix B-IV, gives the results of careful estimates covering the probable use of electricity on the various types and sizes of farms named, which will be found economically desirable and will be adopted when current has been obtained at a practicable,

low rate for a sufficient length of time for the farmers to become acquainted with its real and varied utility. The fact should not be lost sight of that the present stage of development of ways of using electric energy on the farm, and farm equipment suited to be electrically driven, is that of infancy.

FIG. 6. ONE OF FOUR EXHAUST FANS IN DAIRY BARNS AT CARNATION MILK FARMS

COST OF OPERATING HOUSEHOLD ELECTRICAL APPLIANCES

Table IV, Appendix B-IV, contains information for the housewife on the cost of operating various electric appliances.

RURAL ELECTRIFICATION IN CANADA

In Toronto Township there exist rural lines which aggregate 51.7 miles in length and serve an average of 15 consumers per mile. There were attached to these lines in 1922 the following:

Domestic lighting consumers	798
Power consumers	11
Total	809

The energy sold to the domestic lighting consumers during the year ending December 31, 1922, amounted to 435,808 kilowatt hours

qr an average of 45.5 per consumer per month. The revenue received was $27,068.08 and the average amount paid per kilowatt hour 6.21 cents.

The operating revenue is distributed as follows in the Hydro-Electric Power Commission's report for 1922:

Cost of power purchased	$8,862.66
Cost of operation and maintenance	4,817.36
Debenture charges and interest	871.33
Depreciation	2,507.00
Surplus	10,009.73
	$27,068.08

The costs as above given are those to the Municipal Corporation which owns and operates these rural lines, and the surplus is a sum in which every inhabitant of the district served has his proportionate equity. Since all costs of operation including a liberal allowance for depreciation and a sinking fund sufficient to retire the whole investment, including generating and transmission equipment, in thirty years, have been provided for, the surplus might properly have been applied to a reduction of the consumer's bill. Had this been done the current would have been found to cost him only 3.92 cents per kilowatt hour.

Further details concerning the Toronto Township rural lines as also other Canadian rural lines will be found in Appendix B-IV; likewise details of the rural lines in Missouri and in California, from which data on costs per kilowatt hour, placed in comparison in the following diagram (Fig. 7) were drawn.

RURAL ELECTRIFICATION IN GERMANY

In 1902 there were near Hanover in Germany a number of farms, each of 500 acres or more in size, using an aggregate of 2000 H.P. By 1910 electric plows to the number of 28 had been put in operation. One company in Germany is said to have manufactured electric plows during the past year (1923), an output of 160 plows per week having been reached. 40,000 of the 62,208 rural districts in that country are now supplied with electricity. A great variety of machinery, useful on farms, has been adapted to be run by electric motors. Three laws authorizing the state to subsidize the electrification of the district

along the middle and lower Weser were recently passed by the Prussian Diet.

Rural Electricity in Sweden

Of the ten million acres of land under cultivation in Sweden 40 per cent is said to be within reach of electric transmission lines, so that not only country villages but all farmers and craftsmen within the electrified area can be served with electricity. The Government owns extensive hydro-electric plants and about one-third of the total electrified rural area is served by it.

The plan adopted for the financing of rural lines in large parts

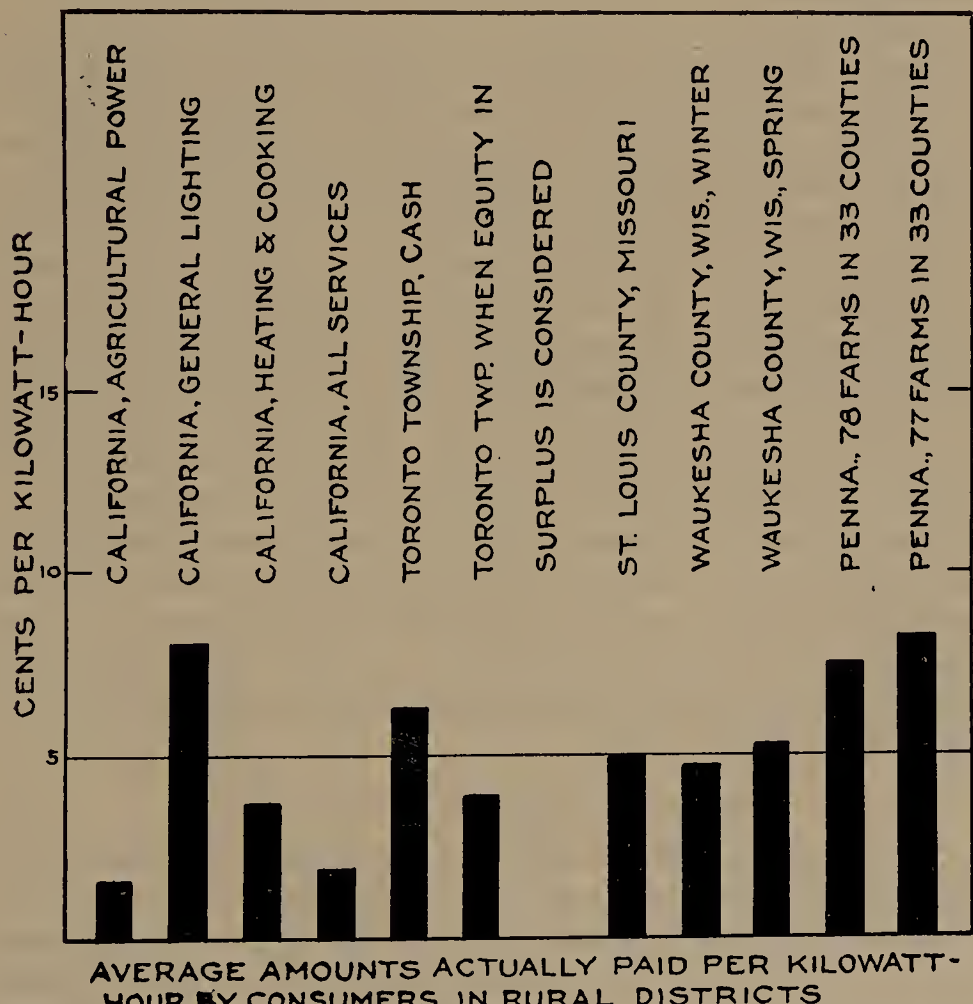

Fig. 7. Comparison of Costs per Kilowatt Hour to Consumers on Various Rural Lines

of the country aims at the forming of local joint interest unions among the farmers, under terms of special legislation, one union embracing an area of about four miles in radius. In this area the union distributes energy to anybody who wants it and pays for it at a uniform established price. Every partner has to sign a one share bond for 50 crowns per hectare (about $5 per acre) of his cultivated ground. These bonds are used as collateral security in obtaining a twenty years' loan with the proceeds of which the lines are built. Electricity has extensive use on Swedish farms notably in threshing.

The *Electrical World*, from which the foregoing information was obtained states:

"Through untiring publicity work and friendly contact, the farmers in Sweden have accepted the idea that it is better for them to show a reasonable tolerance in the matter of service interruptions and voltage regulations, and thus be assured of fairly decent central-station service at reasonable cost, than to insist on a service that could be rendered only at prohibitive rates, if it were made available at all. The Swedish farmer is usually so appreciative of electric service that he does not take unkindly to the use of a kerosene-oil lamp in a pinch or to an interruption of an hour or two in service during threshing time. Farming districts therefore are usually supplied from single lines of simple and cheap construction; reserve equipment is kept down to very moderate cost, and the number of inspectors and trouble men is a minimum." The average consumption of energy is said to be about 16 kilowatt hours per year per acre of cultivated ground. At this rate a farm having 100 acres of cultivated ground will consume close to 133 kilowatt hours per month. A common method of charging for service calls for a fixed yearly charge of 90 cents to $1.10 per acre together with an energy charge of 2⅔ cents per kilowatt hour.

ELECTRICITY ON PENNSYLVANIA FARMS

The Giant Power Survey, some six months ago, sent out 245 questionnaires to farmers in the State of Pennsylvania who were known to be receiving central station service. The list of names was obtained with the cooperation of the State Agricultural Agents located in the various counties. Each agent was asked to supply a list of names for each utility having rural customers in his county. Each list was to contain, if possible, five names made up of farmers having small,

moderate sized and large farms. It was thus hoped to obtain a basis for determining the average conditions as to consumption of current per rural consumer, size of the monthly bill, etc. Responses were obtained from 87 farmers. Not all of the 87 replies contained all of the information requested, hence any one factor such as energy consumption, monthly bill or acres cultivated is averaged individually over the number of farmers replying to these several questions respectively. There are, in any one case, not more than four omissions, however. The following results are from the 87 questionnaires:

	Average
Total acreage of farm	142
Number of acres usually under cultivation	86
Number of horses	4
Head of cattle (incl. milk cows but not calves)	16
Number of calves	4.3
Usual number of cows being milked	10
Number of pigs	12
Number of sheep	1.7
Number of chickens	223

The average number of electric lights installed on the 87 farms are as follows:

In the farm residence	24.7
In the barns	8
In other out-buildings	6.5
In yards	1.4
Total per farm	40.6

The electric equipment in use on these 87 farms is as follows:

Kind of Appliance	*No.*	*Kind of Appliance*	*No.*
Flat irons	83	Brooder	1
Vacuum cleaners	52	Washing machines	57
Electric lighted chicken houses	34	Water pumps	41
Toasters	22	Milking machines	25
Utility motors	13	Hot plates	15
Curling irons	12	Cream separaters	12
Heaters (head light type)	7	Feed grinders	8
		Exhaust fans	5

Kind of Appliance	*No.*	*Kind of Appliance*	*No.*
Heating pads	5	Desk fans	4
Sewing machines	4	Air compressors	4
Battery charges	4	Waffle irons	3
Bottle washers	2	Churns	2
Coffee percolators	2	Ranges	1
Water heaters	1	Soldering iron	1
Dishwasher	1	Hay hoist	1
Meat grinder	1	Saw	1
Thresher	1	Wire embedder	1
Incubator	1	Drill press	1
Drills	2	Vibrator	1
Fire pump	1	10 H. P. motor for silo	1

The average monthly consumption of electric energy of 78 consumers is 128 kwh.

The average monthly bill of 81 consumers is $9.54.

128 kwh. for $9.54 shows average rate to be 7.45 cents per kwh.

If we leave out of consideration the figures obtained from the largest consumer, namely 1974 kwh. for which he paid $59.22 the following averages are obtained:

The average monthly consumption of electric energy of 77 consumers is 104.2 kwh.

The average monthly bill of 80 consumers is $8.55.

104.2 kwh. for $8.55 shows average rate to be 8.2 cents per kwh.

The three larger consumers, after eliminating the largest, use respectively 889, 810 and 423 kwh. per month while the three smaller consumers use 10, 11 and 12 kwh.

The three largest land holdings carried on the returned questionnaires were 950 and 450 and 400 acres, while the smallest were 4½, 7 and 25 acres.

PROBLEM OF REACHING THE FARMS WITH DISTRIBUTION LINES

The central problem of getting distribution lines run to the majority of the farms in Pennsylvania is of course one around which questions connected with widespread rural electrification revolve.

The Canadians have found an answer to this question which may or may not be applicable in this state. In Ontario the Hydro-electric

Power Commission's regulations appertaining to the financing and physical construction of rural distribution lines read as follows:

"The construction of the lines shall be undertaken and paid for by the Commission. The farmers in the vicinity of the roads along which the lines pass will assist in the construction and assistance will be paid for at a suitable rate of wage. Lines constructed from the line on the highway to customers' premises will be paid for by the customer. The Commission proposes to supply the necessary expert labor to direct the construction of the lines and the installation of the equipment. It has been assumed that three farmers per mile of line, or the equivalent are obtainable as an average for the entire district to be served. The supply of poles at low prices in the district or the vicinity of the district by efforts on the part of those desiring service will result in the reduction of the cost of construction and corresponding reduction in the cost of service. Cooperation resulting in the reduction of cost of construction is desired. The rates herein set out are also based upon a government bonus of 50% of the cost of primary lines constructed on the highway or along the right-of-way."

It should be added that the government bonus results in a saving to the consumer of "Light Farm Service" of about fourteen dollars per year and a larger saving to heavier users in proportion to their greater demands.

In addition to the overhead lines referred to in the above excerpt the Commission has evolved a cheap and novel but effective method of laying underground distribution lines. Up to July, 1923, the Commission had in successful operation 150 miles of this underground rural distribution cable. The cable consists of a single stranded copper conductor covered with rubber and enclosed in a lead sheath. The trench is made by a grading plough of exceptional strength, drawn by a caterpillar tractor. The plough is designed to turn a furrow 18 inches in depth. This plough is so constructed as to cut through tree roots 4 inches in diameter.

The tractor is also used to draw a carriage in which the cable reel is mounted and from which it pays out into the trench, and to draw a scraper for refilling the trench. The single wire cable thus laid is used to deliver single phase current, the lead sheath acting in conjunction with the earth as a return circuit. The Commission's engineers place the cost of this underground cable laid and covered

at $800 per mile exclusive of service taps whereas it places the cost of its equivalent overhead construction at $1,154 per mile.

JOINT USE OF POLES

The use of poles jointly by telephone and electric light and power companies is now feasible. Telephone poles as they stand at present, in rural districts, are in general not large enough, in view of their present burden of wires, to permit of the addition of electric light or power wires. At the same time it is clearly apparent that there are many farms served with neither telephone or electric lights which can most economically be reached by joint use of new pole lines when the farmers are ready to adopt both services simultaneously. Both the telephone and electric light and power companies are favorably disposed toward joint use of poles with certain limitations as to voltage.[1]

HIGHWAY LIGHTING

An argument for the lighting of highways and facilities thus provided for reaching farming districts with lines strung upon the same poles as would be used to carry the highway lighting circuits is set forth in Appendix B-IV.

THE FIELD FOR RURAL ELECTRIFICATION IN PENNSYLVANIA

The Giant Power Survey has been to great trouble and expense to ascertain the precise conditions that obtain in each township in the State as regards its area, miles of road within its border, number of farms and farm population, non-farm population outside of incorporated places, and the number of farms having twenty or more animal units. Further particulars concerning these investigations are given in the Appendix B-IV. The Survey has also mapped the areas served by electric distribution lines as distinguished from transmission lines. With the above information as a basis further conclusions have been drawn, as follows:

The electrified area, counting only those localities where service is given comprises close to eleven per cent of the total land area of the State.

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[1]The saving in cost of an ovehead line to a company, through joint use, is from 25 to 40 per cent.

The population of this electrified area is distributed thus:

In cities and other incorporated places	6,036,304
In unincorporated places and not on farms	530,640
On farms	110,011
Total in electrified area	6,676,995

This amounts to 76.5 per cent of the total population of the State.

The distance of the center of each township from the nearest point receiving electric service has been ascertained and each township has been given a figure of merit as regards the number and character of farms which it contains and the productiveness of the locality, value of farm machinery per square mile, the number of farmers owning their own farms, and other significant features.

In each case it has been assumed, based on computation and observation,[1] that, by supplying pole line equal in length to one-half the length of the roads in a township plus the distance of its center from the nearest electrified point at present being served, one-half of its area and three-fourths of its farm population, and three-fourths of its non-farm population not in incorporated places, can be served.

The accompanying curves have been developed on the above basis. For additional pole line amounting to 10,000 to 20,000 miles, the corresponding farm population is closest to points already electrified, and on the average at closest intervals along the road. At the other extreme, where the added pole line will amount to 40,000 to 50,000 miles, are in general farms furthest from electrified points and such as are most widely separated.

The process employed in selecting each succeeding group of townships to be served deferred a township for inclusion in the next group than the one it would otherwise enter, when it was found to be in a less productive portion of the State or had fewer farms having 20 or more animal units per mile of road.

Table VIII, Appendix B-IV, contains details as to disposition of

[1]Curve Fig. 10, was developed on the basis that the population of a township, as a whole, or in its several parts independently, varies uniformly from none per mile to twice the mean density per mile.

The curve is rigidly correct for the assumed conditions but gives a smaller population per mile of line than can ordinarily be served due to the fact that concentration will usually produce a density greater than twice the mean value at some points.

classes of consumers, with increasing mileage of new line, for townships having a density of two or more farms per mile of road.

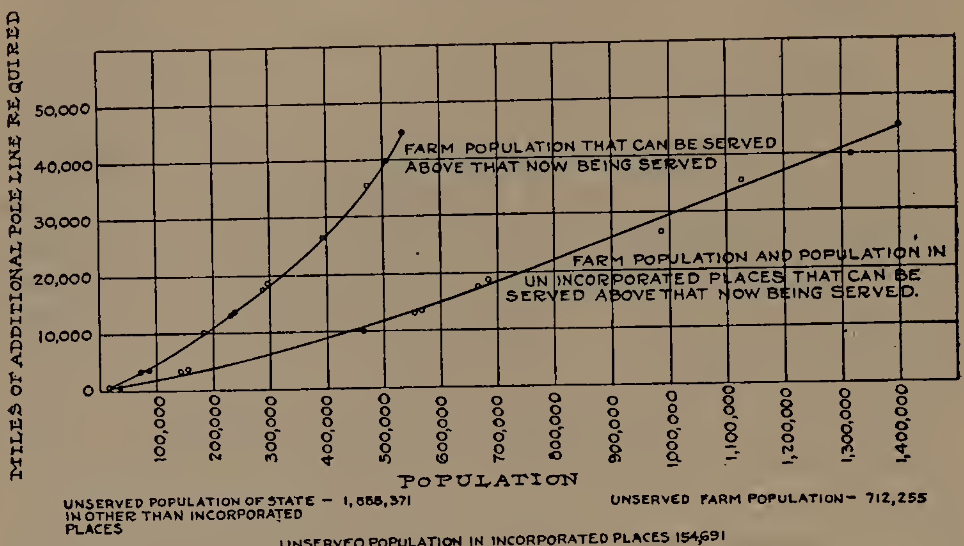

FIG. 8. RELATION OF POPULATION THAT CAN BE SERVED TO LENGTH OF POLE LINES REQUIRED

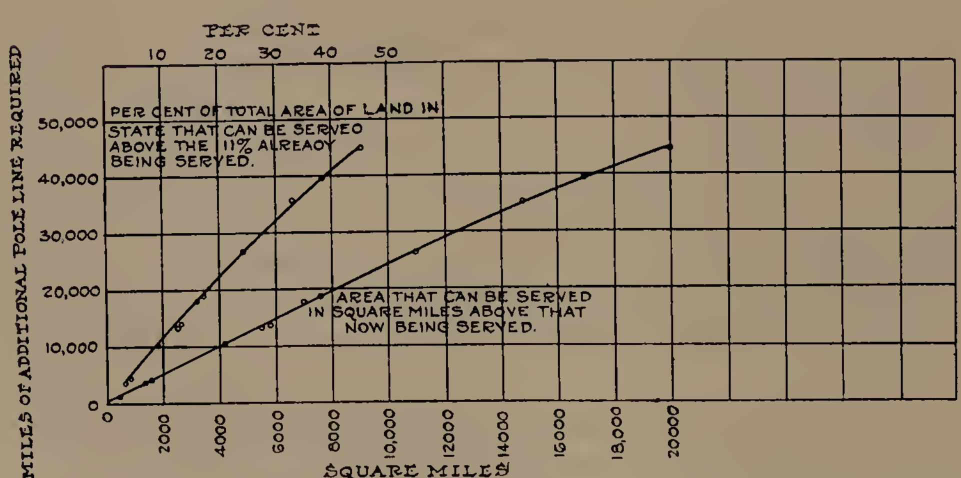

FIG. 9. RELATION OF AREA THAT CAN BE SERVED TO LENGTH OF POLE LINE REQUIRED

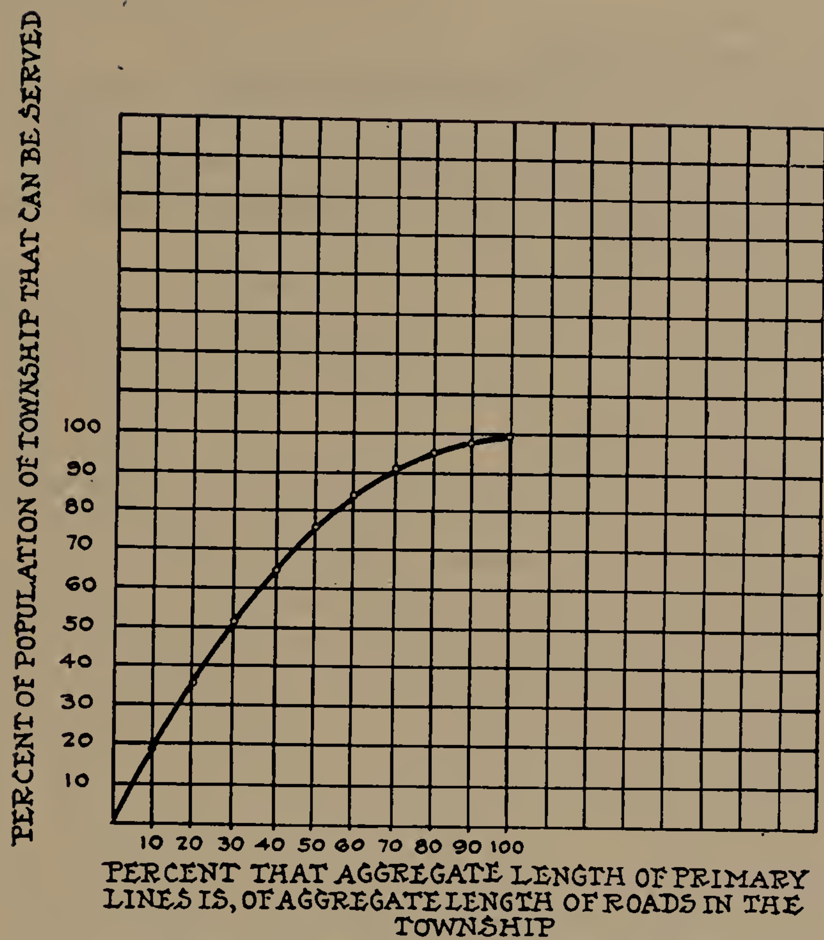

FIG. 10. RELATION BETWEEN RATIO OF TOWNSHIP ROAD LENGTH TO LINE LENGTH, AND POPULATION SERVED

THE HOPE OF THE FUTURE

A wide-spread electrification in rural districts attended, as it is bound to be, by a decentralization of industry, is the best hope for the further social, economic and industrial expansion of this nation. When factories move to the country, the consumers of farm produce will have come close to the farm. Factory workers will be comfortably sustained in the vicinity of their work and their number, for this reason, increased. Farm laborers will have an outlet for their energies at seasons when the land cannot be profitably worked. Where farms have become electrified capital will be used more effectively on account of the abundance and increased productiveness of labor, and more capital will become available as profits accrue. Electric energy

at any reasonable price is far less costly than that derived from the muscles of man or animal.

Finally no self-respecting portion of a great Commonwealth can long endure facilities for living inferior to those enjoyed by a majority, without grave injury to its morale. Making electric power available to the people of the rural districts will again bring the countryside into its own.

Technical Report No. 6

A GIANT POWER INDUSTRY

By Otto M. Rau, *Consulting Engineer.*

The Giant Power Survey studies indicate that there is no inherent economic association between electric power production and the business of distributing the generated current to the consumers.

The production of power is a mass manufacturing problem, while the basic function of a public utility furnishing electric service is to develop effective and efficient distribution of a commodity. In reality, at the present time an electric power utility functions largely as a power sales organization. "Service" and not power is the commodity which these companies insist that they are supplying to the public. This fact is further evidenced by the tendency to separate the manufacturing plant from the electric utility selling organization. New power developments over the country are usually organized as separate companies, their prime purpose being the manufacture of power. The output of these plants is contracted for by the electric service company.

The manufacturing cost of power has become of minor importance in the ultimate rate to the consumer. Rates are more and more based on the "cost of service" rather than on the cost of power. This condition greatly retards a healthful growth and wide-spread use of electric power. Many industries and particularly rural communities are not interested in service from the standpoint of metropolitan areas, and the rates include service which they not only do not want, but in most cases, do not get.

By the development of a power industry, through which power as a commodity can be purchased in quantity at cost plus a manufacturer's profit by anyone capable of using a sufficient amount (comparable to a standard package in other manufactured products) to warrant delivery, utility companies will be relieved of providing any manufacturing plants, and can confine their efforts to the sale of the service, being assured that the cost of the power they are distributing is obtained at a cost at least as low as it could be secured from a manufacturing plant they owned or controlled, or from which they

contracted the entire output. The rural communities, by grouping their power requirements could obtain their supply at the same cost and provide such service facilities as would meet their needs or standards.

Perfect (infallible) service is impossible. The degree to which perfection is demanded is reflected in the rate. A metropolitan district demands as perfect service as human intelligence and effective management can produce. Rural service requires the least of such effort to develop such a high class of service, and for the farmer the consumers' cost of power may easily be close to the manufacturing cost. For suburban and interurban consumers the cost increases depending upon the standard set for service, until the metropolitan areas are reached, where present standards may even warrant the enormously large difference between manufacturing cost of power and the rates at which it is sold to the local consumers.

To produce power at low cost, mass production must be applied in the full meaning of the term, "from the mine to the distributor" (Ford Methods) including the efficient transportation to distributing centers. This calls for a *Giant Power Industry.* The development of such an industry can be accomplished by the cooperative efforts of the electric power utilities and the State, bringing about an unlimited supply of power to the utilities and a wide-spread use by rural and other communities not now adequately served. Elsewhere in this report natural resources available for such a development are described. The principal factors in such a development are as follows:

Location:

Dr. Newell has made thorough analysis in Technical Report No. 3, of the natural power resources—both coal and water. He has selected a number of locations where Giant Power plants can logically be placed. Those most favorable are on the Allegheny River in Armstrong County. And with artificial cooling the range of choice is widened.

Capacity:

From the statistics tabulated in Technical Report No. 1, "Power, Its Production and Utilization," a conservative capacity for a power industry to supply the needs of a Giant Power system in 1930, will be 2,000,000 kw. at a 60 per cent load factor. This

would supply a base load source for a period of ten years. The installation should have an 80 per cent load factor in view.

Transmission:

The rapid strides made in recent years for quantity delivery of power over long distances has so simplified the problem of transmission that distances as far as the demands for Pennsylvania are concerned are easily met. With the extensive network of high tension lines now in operation in the State, a simple system of trunk transmission lines so placed as to intersect the existing lines would avoid the necessity of constructing competing or paralleling lines by the public utilities. Originating at points where power can be produced economically they would control and provide an unlimited source of power for distribution over the lines now installed. With such a trunk transmission system once laid down all further line construction could be executed on an economic and efficient basis.

Costs: A—Power Plant.

An industry for the production of power on a scale such as proposed by the Giant Power Survey can be installed at less cost than the smaller plants for the manufacture of power now being erected, and for the purpose of this report a figure of not to exceed $75 per kw. prudently invested—is assumed.

B—Transmission.

The difficulty in arriving at costs where rights-of-way are involved leaves an estimate for a trunk transmission line a matter of approximation. However, with public support for such an undertaking and with the proper utilization of existing lines and rights-of-way, we can use for this item even a top figure in making our estimates. The assumptions made by recent experts in similar investigations, estimated at 20 cents per kw. mile[1] will be used for the purpose of this report.

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[1]See Plate II, Super Power Studies by N. E. Superpower Committee under direction Hon. Herbert Hoover.

Operation:

Based on modern power plant design, with an efficiency of 16,000 b. t. u. per kwh. and a by-product development as outlined by Mr. Dickerman in Technical Report No. 4, "Pretreatment of Bituminous Coal" the production costs (including capital costs) may fall below 2 mills per kwh. So that with a 60 per cent load factor the cost to a distributor need not exceed 3 mills per kwh. at the power plant bus bar, and leave a margin for profit.

Cost to Distributor:

Distance being the controlling factor in transmission charges therefor should be levied by zones. The whole charge will be arrived at by adding to the manufacturing costs the operating costs of trunk transmission lines, line losses and fixed charges and profit. Assuming zone districts at 50 miles the cost of power at the primary sub-station incoming line based on an average 10 per cent transmission loss, plus operating and maintenance costs of transmission, and profit, will be as follows:

First zone—3 mills power cost plus 2/10 mills = 3.2 mills
Second zone—3 mills power cost plus 4/10 mills = 3.4 mills
Third zone—3 mills power cost plus 6/10 mills = 3.6 mills
Fourth zone—3 mills power cost plus 8/10 mills = 3.8 mills
Fifth zone—3 mills power cost plus 1 mill = 4. mills
Sixth zone—3 mills power cost plus 1-2/10 mills = 4.2 mills

A Giant Power industry capable of providing a power supply such as is contemplated would approach in magnitude, both physically and financially, considerably less than the aggregate of the individual developments of the utilities operating in Pennsylvania. It would provide in common for all utilities their future power requirements at a cost based on economic production as contrasted with the individual company's ability to reach an economic source.

The construction program would contemplate the immediate equipment of the plant to its full original designed capacity and would operate at this capacity as soon as completed. This would avoid investment and capital charges on construction costs for anticipated extensions which in many instances are never utilized, in addition to

increased operating costs as the anticipated economy is based on the completed plant.

Fundamentally this means the placing of prime power sources near the location of natural fuel resources. The successful development of artificial cooling of condensing water by plants similarly located, where only limited quantities of water are available, removes the most difficult problem in the selection of such locations. The recent development in high voltage transmission eliminates distance as a factor in Pennsylvania, and with public support in providing a wide-

Fig. 1a. Power Plant at Mine, Golpa, Germany

spread distribution and in assuring the permanency of such an industry, rapid progress toward its realization is possible.

The giant-like proportions which this industry will assume are not unreasonable as compared with other modern engineering achievements, although out of scale with those developments possible through the action of individual companies. The pre-treatment of the fuel, not only of that portion required for power but of the entire output of the mine, links the power plant with an industry now foreign to a power utility.

A Giant Power industry contemplates a location within a reasonable radius of mines having a combined capacity of 25,000 tons of coal per day for not less than 50 years; a coal distillation plant capable of pretreating all the coal mined using the high grade product for domestic and industrial fuel and pulverizing the balance for the production of power; the use of cooling towers where water is insufficient for the economic operation of the plant (Figure 1); the installation of sturdy, large prime movers capable of continuous operation for years without interruption; the aggregate capacity in one plant to be not less than 500,000 kw.; transmission systems at high voltage with capacities of 250,000 kw. per tower line.

With proper cooperation between utilities and the State a power industry is possible, which will conserve the natural resources of Pennsylvania, supply a smokeless fuel for our homes and industries, relieve transportation, provide an unlimited supply of power, and assure the healthful expansion and continued dominance of Pennsylvania's industries. All of which, in the light of modern knowledge, is necessary for our future welfare and comfort.

The scope of our survey—in fact a reconnoissance—precludes great detail in the plans for a project of such magnitude as a Giant Power Industry. It is, however, necessary to arrive at such conclusions as are herein cited to assess the financial requirements and the probable reasonableness of the conclusions.

The development of cheap power means quantities heretofore inconceivable. The major problems which confront power production at present are automatically solved when generation in such quantities is brought about. The industry reaches such magnitude that details of construction and operation are surrounded with advantages not possible in the usual power plant. The fact that a Giant Power source becomes a base load plant operating at its economical capacity continuously eliminates difficulties which are of the first importance in the individual plant producing power only for local distribution. The location, as fully indicated by the reports in this survey, not only from economic consideration but inherently, must be at the source of raw material. Giant Power plants must have such other natural advantages as will allow the development of the industry as a whole, and markets to dispose of all by-products and residue, which of course become available in vast quantities. Such an industry makes reference to present practice impossible.

The manufacturing cost of power to give this conception reality must be so low that existing sources of the largest and more efficient type will be attracted as purchasers of the output and will avail themselves of this source of energy for their fixed or base load power using their own plants for standby or intermittent service.

Fundamentally, a Giant Power industry plans to eliminate all waste in power production and starts by affecting economies in the use of raw materials, the reduction of such materials to a point which leaves only the least valuable residue for power production, the

Fig. 1b. Power Plant at Mine, Hirschfelde, Germany

minimum handling and conveying of all material and a comprehensive plan for disposition of all by-products. All these steps must be accomplished by developed and recognized processes, but by a combination sufficiently large to make a balanced industry and on a scale to accomplish the desired results.

To arrive at overall figures available material on costs has been consulted and unit prices obtained which represent consistent averages applicable to an undertaking of this size. Wherever possible data from plants actually constructed have been used. From these figures an estimate of the cost of a Giant Power industry, having a manufacturing capacity of 500,000 kw. at an 80 per cent load factor, with efficient operation at a load factor of 60 per cent, is arrived at.

The plant site, being in the coal mining district, can be acquired at less than the cost of that usually paid for power plant sites located in or near industrial centers. It is estimated to cost not to exceed $250. per acre and that an area of 180 acres is required.

The buildings are to be of the factory type consisting principally of foundation and supporting structures for the equipment, with skeleton enclosures to protect the machinery similar to a steel mill or industrial plant, the costs of which are estimated at 20 cents per cubic yard for foundation and 15 cents per cubic foot for super structure.

Dams, intakes, canals, cooling towers (if necessary) including all costs to provide water for condensers and boilers are covered by an overall figure conservatively estimated, details being difficult to arrive at in a preliminary study of this kind.

Railroad sidings, trestle and yard facilities for coal handling are based on a unit cost estimated from similar work for power plants which handle large quantities of coal.

The coal treatment plant presents the most difficult problem in arriving at a dependable estimate. Of the several processes covered in the report of "Pre-treatment of Bituminous Coal" the only installation in actual operation with capacities such as are required for a Giant Power industry is that referred to as the "High Temperature Coking Process." The product of this process—metallurgical coke—produces a fuel of too great a value for power plant use. Of the low temperature process, the only one plant having a capacity sufficiently large from which approximate costs can be estimated is the plant of the Clinchfield Coal Products Corporation designed to treat one million tons per year. This plant was completed for a capacity of only 500 tons daily. By using the construction cost of this plant as a basis from which to reach an overall figure, a sufficiently accurate estimate can be obtained. The coal treatment plant to supply a low cost fuel for power plant use must be capable of treating not less than three times the actual amount of fuel required for power generation. Only that portion of the coal carbonized, not suitable for shipment as domestic or industrial smokeless fuel, is to be used for producing power in the Giant Power plant.

The capacity of the coal treating plant will therefore be based on 25,000 tons per day which is the size of the high temperature coking plant at Clairton, Pa.

Power plant equipment is based on the cost per kw. of each class of apparatus including installation and foundation costs, obtained principally from published statements covering these items. The installation contemplates the simplest design of unit construction consisting of boilers, generating equipment and step-up transformer, with necessary auxiliary apparatus constituting one unit, of 75,000 kw. capacity, without interconnection, excepting an outdoor transformer bus for the transmission lines. Due to the high voltage of the transmission system no lightning protection is considered.

The transmission system contemplates following generally the direction of the steam railroads crossing the state by the most direct route. It is on these lines and near them that the great industrial activities are carried on. It may become possible to utilize such parts of railroad rights-of-way[1] as would not interfere with railroad operation and thus add to the value of railroad property. The difficulty of estimating right-of-way costs is apparent. For this item $1500. per mile of trunk line, having 500,000 kw. capacity is considered a liberal estimate. These trunk lines will consist of double tower construction each tower carrying six wires or two three phase circuits of 125,000 kw. capacity at 220,000 volts, with an average energy loss of 6 per cent at 60 per cent load factor. A distance of 300 miles is assumed as the maximum length of line without step-down transformer equipment. The step-down sub-station should be considered as the distributor's property at each point where service is delivered for local distribution. Estimating the above costs and classifying them in accordance with the Standard classification of accounts as required by the Public Service Commission, the total investment for construction would be as follows:

Distributed Capital Account:

Account No.		
204	Land	$49,000
	Coal Treatment Plant, Capacity 25,000 tons daily	34,000,000
	Fuel Preparation Plant, Crushers, pulverizers, conveying, etc.	2,460,000
207	Generating System, Power Plant structures, canal work, etc.	1,900,000

[1]See *Electrical World* editorial, issue October 18, 1924.

Distributed Capital Account:

Account No.		
208	R. R. Sidings, Trestles, etc.	50,000
209	Boiler Plant equipment, furnaces, burners etc.	8,900,000
210	Accessory equipment, condensers, pumps, etc.	6,800,000
211	Turbo Generators, foundation, etc.	13,000,000
212	Other elec. gen. exciters, etc.	450,000
213	Other elec. equipment, switching plant, etc.	900,000
214	Coal storage and weighing, etc.	250,000
215	Other power plant equipment	150,000
	Total	$68,909,000

Transmission:

239	Right-of-way	$450,000
240	Towers and fixtures	6,000,000
243	Overhead conductors	8,000,000
244	Telephone system	500,000
	Total	$14,950,000
	Grand total	$83,859,000
	Less Coal Treatment plant	34,000,000
	Power Plant and transmission	$49,859,000
	Trunk line Transmission	14,950,000
	Power plant (approx. $70 per kw.)	$34,909,000

The operation and maintenance of a Giant Power plant will vary but little from that of the larger plants now operating in this State. The basis of these estimates is taken from such data as is available from the power companies operating large plants in Pennsylvania and elsewhere.

The diversified activities of a Giant Power Industry including such sub-industries as mining, coke, oil refining, coal, etc., would require an exhaustive report on each activity to arrive at detailed

operating expenses. As this report is confined to power production no attempt will be made to analyze the operating costs other than those directly affecting the production and transmission of power.

The largest single item included in the operating costs of a power plant is fuel. It is therefore important to give this careful consideration. The cost of coal at the mine is well established and while economies over present production cost are easily possible, particularly where continuous operation at a predetermined capacity is assured, a price of $2.16 per ton at the tipple is assumed as a liberal figure for the cost of coal where a continuous daily output of 25,000 tons is contemplated. In Technical Report No. 4, Mr. Dickerman has established the fact that the processing of coal before it is used in the power plant can be made to yield a profit. With the treatment of 25,000 tons of raw coal daily and the use for power production of only that portion of the treated coal which is not suitable for shipment, the actual cost of this coal will be very low. It is conceivable that if all the profits from the sale of by-products from distillation including the excess gas produced, and the profits from the sale of a smokeless fuel as a substitute for anthracite coal for domestic and industrial use were credited to the fuel account of the power plant, it would show a considerable credit balance without any charge for the fuel used by the plant. It should be kept in mind that we are here sketching in broad outline an industry on a scale out-reaching anything heretofore conceived, but one which is apparently well within our grasp through a synthesis of available means. This means that for reconnaissance estimates such as we are here attempting, the net cost of fuel at the power plant must be affected not so much by the point of view of the estimate or as to his assumptions, as by the brilliance and daring used in the accomplishment of possible results.

If we accept the point of view of the social economist that for the Good Life we cannot have too generous a supply of such inherently valuable commodities as results from the low temperature distillation plant and, further, if we assume that previous experience in the disposition of high temperature by-products will be repeated, then we can assume a high net profit from our coal distillation just as Mr. Ford does. To be conservative a nominal charge of 25 cents per ton is assumed as the cost of fuel delivered in the bunkers at the power house.

This fuel in the form of a semi-coke is estimated to have a heat

value of not less than 12,500 b. t. u. per pound as delivered. The overall efficiency of the plant at a 60 per cent load factor is estimated to exceed 18,000 b. t. u. per pound of fuel and will require 5,000 tons per day.

All other operating and maintenance costs being arrived at from figures available from existing large power plants the estimated operating and maintenance costs tabulated in accordance with the classification of accounts of the Public Service Commission are as follows:

Coal Treatment Plant:

No details prepared as sale of by-products is estimated to cover operating expenses and fixed charges.

Operating expenses, Power Plant:

Account No.		
350	Superintendence	$48,000
351	Boiler Labor	264,000
352	Engine Room Labor	48,000
353	Electric Labor	28,000
354	Other Labor	42,000
355	Fuel Semi-Coke, 13,000 b.t.u. Fuel required (2½ billion kwh. @ 18,000 b. t. u.) 1,435,000 Tons (2000 lb.) @ 25c	359,000
358	Water treatment and purification	100,000
359	Lubricant	30,000
360	Boiler Plant supplies	96,000
361	Boiler plant expenses	12,000
362	Other power plant supplies	12,000
363	Other power plant expenses	6,000
364	Superintendence and other emp. exp.	3,000
365	Maintenance Power Plant Structure	180,000
366	" R. R. sidings and trestles	60,000
367	" Boiler plant equipment	
368	" turbines	
369	" turbo-generator	
370	" other elec. gen.	1,000,000
371	" other elec. equip.	
372	" Coal weighing equip., etc.	
373	" Other power plant equip.	

Total power plant operating and maintenance	$2,288,000
Maintenance (approx. .0005 per kwh.)	1,240,000
Operation (approx. .00042 per kwh.)	$1,048,000

Operating expenses, transmission:

Account No.		
415-420	Operating Labor	$45,000
421-426	Operating supplies & expenses	50,000
427-434	Maintenance Transmission equip.	150,000
	Total transmission expense	$245,000
	Maintenance Ex. at .00006 per kwh.	150,000
	Operating ex. at .000034 per kwh.	$95,000

Fixed charges as applied to production costs are arrived at by following the classification prescribed by the Public Service Commission which include the following items:

Organization (No. 200) which item covers all capital required other than that covered by Distributed Capital Account.

Distributed Capital Account consists of the items listed in the estimate of construction costs.

Engineering and Supervision during construction (No. 268) covers all expenditures for preliminary engineering, consulting engineering and inspection and supervision or any engineering or supervision not covered by the estimate of construction costs.

General Office Expense (No. 289-293) are covered in the item of "Omissions and Contingencies."

Insurance (No. 293-294) covers all expenses necessary to protect against loss from injuries and damages, fire or other liabilities during construction.

Taxes during construction (No. 295) are covered in the item of "Omissions and Contingencies."

Interest during construction (No. 296) covers all funds required to pay interest and commissions or discounts to provide funds during the construction period and until the industry is in productive operation.

Omissions and Contingencies cover any items not otherwise specifically classified, and is an arbitrary and adequate amount.

The Total Fixed Capital Account represents the money "prudently invested" to produce the completed industry ready for operation, and is itemized for each plant, as follows:

FIXED CAPITAL ACCOUNT

Fuel Treatment Plant—sale of by-products estimated to cover fixed charges.

No.		*Power Plant*	*Trans. System*
	Distributed Capital Account	$34,909,000	$14,950,000
200	Organization	300,000	200,000
288	Engineering and Supervision	1,000,000	250,000
293-4	Insurance	100,000	50,000
296	Interest during construction	1,000,000	450,000
	Total capital account ...	$37,309,000	$15,900,000

FIXED CAPITAL CHARGES

No.		*Power Plant*	*Trans. System*
703	Interest @ 5 per cent	$1,865,450	$759,000
751	Reserve Accounts		
	Insurance reserve	50,000	25,000
	Injuries and damages	50,000	25,000
	Renewals and replacements	100,000	25,000
	Amortized capital ex.	200,000	100,000

Total fixed charges,
Power Plant (.0009 per kwh.) $2,265,450
(.0009 per kwh.) ... $2,265,450
Trans. System (.00038 per kwh.) .. $934,000

RECAPITULATION

	Power Plant	*Trans. System*
Capacity	500,000 kw.	500,000 kw.
Voltage	13,000 volts	220,000 volts
Generation	2,750,000,000 kwh.	2,500,000,000 kwh.
Capital Account	$37,309,000	$15,900,000

Fixed Charges	$2,265,450	$934,000
Operating Expenses ..	1,048,000	95,000
Maintenance Expenses	1,240,000	150,000
Gross Operating Costs	$4,453,450	$1,179,000
Per Kilowatt Hour		
Fixed Charges	.0009	.00038
Operating Expense ..	.00042	.000038
Maintenance Expenses	.0005	.00006
Gross Production Costs	.00182	.000478

The manufacturing cost less a profit being .00182 per kwh., a rate of 3 mills per kwh. at the station bus for power at a 60 per cent load factor will leave for administration and profit $2,950,000.00 which is in excess of 10 per cent on the Capital invested in the Generating plant.

Transmission costs will vary according to length of transmission distance. On the basis of the entire output being delivered at the terminal of the 300-mile line, the cost being .000478 per kwh. a rate of 1.2 mills per kwh. at the incoming primary line of the sub-station will leave for administration and profit $1,805,000.00 which is in excess of 10 per cent on the Invested Capital in the Transmission System.

Proposals for Legislation

By PHILIP P. WELLS,

Deputy Attorney General and Member Giant Power Survey Board

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INTRODUCTION

The rapid advance of the art of long distance transmission has now made it possible to send electric current from end to end of and throughout Pennsylvania, so as to serve all users in every part of the Commonwealth at a cost less than that of hauling over the same distance coal for the generation of the same amount of power at or near the places of power consumption. The public interest requires that the cost of generation, transmission and distribution be reduced to the lowest terms consistent with safety and efficiency; that needless waste be stopped, both to reduce costs and to prolong the life of the coal deposits; that investors in the power business be assured of an opportunity for a profit sufficient to attract new capital in sufficient

volume; and that the output be distributed in practically universal service without discrimination throughout the state at the lowest prices consistent with such a fair profit.

The General Assembly of 1923 imposed upon the Giant Power Survey Board the task of finding ways and means to attain these ends.

WATER POWER

The two great natural resources at present available for the production of power are falling water and mineral fuel deposits. The water power resources of Pennsylvania are very meagre for our needs, but to a certain extent they may be and should be supplemented by those of New York, Maryland and West Virginia. The development and utilization of the limited water power resources of Pennsylvania, upon the general principles above set forth, was provided for by the Limited Power and Water Supply Permit Act of June 14, 1923 (P. L. 704) and the accompanying Condemnation Act of the same date (P. L. 700). These statutes have worked well. Under them two great water power developments have already been initiated.[1]

STEAM GENERATION OF ELECTRICITY

The principles of the said two Acts of 1923 should now be applied to the development and utilization for public service power of the mineral fuel resources of the State. Those Acts did indeed aid public service power development from mineral fuels by granting the right of condemnation for storage and cooling works to supply water for steam raising and steam condensation, a matter of

[1]The permit act should be clarified as to projects for the storage or cooling of water for steam raising or steam condensation in the generation of public service power. Further aid for water power development should be given as follows: Sanction by statute the long standing practice of the Governor's office to refuse patents for Commonwealth-owned islands in all rivers of the State as the law now requires with respect to the Susquehanna; authorize mergers, subject to Public Service Commission approval, of hydro-electric and steam electric companies; make an outline survey to designate tentatively the available water power sites in the state and make the consent of the Water and Power Resources Board a condition precedent to the location or construction of any adverse public service easements within the designated sites. On the other hand it is but fair that land in power reservoirs should be taxed by the respective counties on the basis of the value of farm lands in the vicinity. Otherwise hardships in the shape of heavy tax burdens fall upon the thinly populated hill regions.

vital importance since some 400 pounds of water are at times used in steam condensation for every pound of coal burned. But our laws have never comprehensively dealt with or systematically aided or guided public service power production from mineral fuel deposits upon the scale demanded by the recent advance of the art of electric transmission. This notwithstanding the facts that the coal deposits of Pennsylvania are the source of a great part of all the mechanical and electric power produced for public and for private use in the Northeastern United States, that they are exhaustible within a time relatively short, that they are needlessly wasted and loaded with needless costs by present methods of use. It is the chief business of this report to suggest measures for such aid and guidance.

Giant Power Permits for Generation and Transmission

To secure the economies of mass production in the generation of electricity for use in public service, together with the elimination of freight charges for long hauls of coal, and the reduction of fuel cost by the distillation of by-products instead of burning the raw coal, plants of great size (300,000 kw. and upwards) should be placed at or near adequate coal deposits, and when feasible near sufficient supplies of condensing water either existing or capable of economical development. Sites meeting all these requirements are few. To this end "giant power permits" should be issued by a permanent Giant Power Board (being essentially a matter of resources disposal.) An applicant should first show the adequacy of the proposed generating site, of the nearby coal and water resources, of his financing scheme and of his plans of development, including generating plants of not less than 300,000 kw. capacity and the general location of a giant power transmission line or lines of not less than 110,000 volts pressure, and showing all existing high tension lines which can be supplied by being connected therewith. The definite location and points of connection should be left open to final determination by the Board. The Board should have power to require in any permits greater generating capacity than 300,000 kw. and higher transmission pressure than 110,000 volts.

The Giant Power permittee should by incorporation be empowered to generate electric current, and sell it at wholesale within the Commonwealth to electric distribution companies and municipalities for use in public service; also to mine coal and to conduct a subsidiary busi-

ness in coal, coke, gas, chemicals and other by-products; also to exercise the right of eminent domain as noted below.

Giant Power permits should be limited to terms not longer than 50 years and the works should be subject, at the end of that period, to "recapture" by the Commonwealth or a subsequent giant power permittee upon repayment of the capital prudently invested. The permit should fix the conditions upon which the corporate powers of the permittee are to be exercised, and in particular should subject his wholesale disposal of electricity to the approval and regulation of the Public Service Commission. These conditions should include reasonable precautions against stream pollution by the processes of by-product recovery and manufacture and against the overheating of streams, which is already a menace to industrial property in the iron and steel regions.

The Giant Power Board should select, designate and acquire for the Commonwealth by purchase or condemnation land strips of sufficient width and suitably placed for the location of Giant Power transmission lines. The right to use these strips for this purpose and for other public purposes such as gas pipelines, oil pipelines, etc., should be granted by the permit of the Giant Power Board. When such strips are not available Giant Power permittees should have the right to take, by eminent domain, rights-of-way for their transmission lines. Lands servient to rights-of-way for railroads and highways should be made servient to use by high tension transmission lines, including Giant Power transmission lines, subject to the approval of the Giant Power Board.

CONDEMNATION OF COAL DEPOSITS

Giant Power permittees should be clothed with the right of eminent domain to take any and all interests in lands, waters and other property necessary to efficient construction and operation, especially coal deposits sufficient for operation during the term of the permit, on a leasehold basis, subject to royalty fixed by the condemnation proceedings, and secured before the taking. The right of eminent domain should be exercised by them and by other power companies only under the close supervision of the Giant Power Board after a finding that the taking of the specific property in view is required by the present and future interests of the Commonwealth and is not incompatible with the public interests of the vicinity.

Giant Power companies should be authorized and required to purchase and to resell to distribution companies surplus electric power produced by public service companies such as railroads and traction companies and by generating plants other than those in public service (mills, etc.), the prices and conditions of purchase and resale and the conditions of receipt and delivery to be subject to regulation by the Public Service Commission. Offerings in excess of demand and demands in excess of the capacity of connected generating companies to be reduced *pro-rata* to the practicable quantity, but the output of giant power steam stations should not thereby be reduced except in favor of hydro-electric stations, nor should their purchasing price exceed their own generating cost.

SEPARATE CORPORATE OWNERSHIP OF GENERATION, TRANSMISSION AND DISTRIBUTION BUSINESS

To make sure that the energy generated by Giant Power plants is distributed on just and equal terms regulated by the Public Service Commission, and extended systematically throughout the State, all major transmission lines (of over 50,000 volts or 25,000 kw. capacity) must be common carriers. Therefore, the three businesses of generation, except by Giant Power plants and by small plants (of less than 25,000 kw. capacity), transmission, and distribution (including minor generation and minor transmission), should be segregated in separate corporate ownerships. Dealings by the generating corporations with the distributing corporations and by each of them with the common carriers between them, should be subject to Public Service Commission regulation.

INTERSTATE COMMERCE—FEDERAL REGULATION

The segregation of high tension transmission in separate corporate ownership from generation on the one hand and distribution on the other, seems necessary also for the maintenance of the regulative authority of the states in view of the recent decision of the United States Supreme Court in the case of Missouri *vs.* Kansas City Gas Co. rendered May 26, 1924. Adv. Op. 585, wherein the business of a natural gas company which produced gas in one state, carried it to another by pipe line and sold it there at wholesale to a distributing company was held to be interstate commerce beyond state regulative control, notwithstanding that Congress had not attempted to exercise Federal control over it. The possibilities of abuse in a like situa-

tion as to interstate commerce in electricity, as well as the scope of the Federal control that experimence with railroad regulation indicates will in the end be necessary in the absence of such segregation, may be reduced to their lowest terms by placing the operation of interstate transmission lines in corporations which are forbidden to operate generating stations or distributing systems in Pennsylvania.

INTERSTATE COMMERCE—COMPACT WITH OTHER STATES

The ultimate integration of electric service throughout the Northeastern region of the United States without regard to state boundaries is clearly indicated by the progress of the art of transmission and the news of corporate combinations in financial journals and newspapers. This new interstate commerce will require public regulation. The centralization of this task in Washington would place a heavy burden upon any Federal Agency that might be entrusted with it, even if limited to wholesale transactions. If harmonious and stable action by the States could be secured it would be a better course to entrust the task to them. An interstate compact approved by Congress under Article 1, Section 10, paragraph 3 of the Constitution of the United States seems the best means for securing harmony and stability. But this will require a substantial unity of aim in all the states concerned. The promotion of such unity in policy and of interstate compacts to give it effect is a task that might properly be given to the Giant Power Board.

INTEGRATION

The economies of mass transportation and favorable load adjustments resulting from integration of electric service over a large territory have been shown by other papers accompanying this report and are fully recognized in the best and most recent practice in the electric industry. The process of integration is clumsily going forward by corporate mergers and combinations of all kinds, sometimes involving unwarranted costs which at last consumers must bear, generally guided by commercial rivalry and therefore inevitably without due consideration of the broadest public interests.[1] It is necessary that all obstacles to complete integration be removed and that its achievement be required of the electric companies as one of their public duties.

[1] 386 new electric companies were organized in Pennsylvania in 1923, and over 200 in the first nine months of 1924.

Transmission Lines to be Common Carriers

The principle of exclusive service territory now applied to distribution should therefore be extended to the segregated transmission business. The State should be divided by the Giant Power Board into transmission districts upon the basis of present facilities and future needs as they from time to time may be foreseen or arise. All public service transmission lines of more than 50,000 volts or 25,000 kw. capacity should be common carriers, under regulation by the Public Service Commission, for the districts assigned to them, charged as such with the duty of taking electric current of standard voltage and frequency from Giant Power companies and all generating stations in the state and delivering it to their consignees, being public service distribution systems in the district, and to other transmission lines. The rates of transmission and all conditions of the service should be regulated by the Public Service Commission. This will apply to public service power the principles already applied to railroad, telegraph and telephone service by existing law and practice.

Distribution—Municipal Systems—Incorporated Districts—Consumers' Mutual Companies

To extend electric service to regions otherwise not likely to get it, municipally owned and operated electric systems should be permitted to furnish service to unserved nearby territory at the discretion of the Public Service Commission. The same rule should apply to companies chartered to serve incorporated places. Provision should be made for the incorporation of rural electric districts upon the favorable vote of a sufficient majority of inhabitants and of the owners of a sufficient majority of the acreage. Such districts should have power to furnish electric service to their inhabitants and to others nearby, also to tax, assess benefits and damages, finance construction work, etc. Provision should also be made for the organization of consumers' mutual electric companies. All these should have an equal right with other distributing systems to purchase current from gaint power and other generating companies for delivery by common carrier transmission companies. These electric service districts and consumers' mutual companies should receive State aid in the form of expert engineering, accounting and management advice, as farmers are now advised by experts in farm management, farm accounting, domestic science, farm crops, animal husbandry, fruit raising, and the

like. Regions conspicuously without service should be investigated by the Giant Power Board for determination of and report to the General Assembly upon the advisability of State contributions toward the cost of rural lines such as are made by the Provincial Government of Ontario and in several European countries, and, if advisable, the methods to be followed in making such contributions. State aid for highways is generally accepted as sound in principle and beneficial to the whole Commonwealth. Is this principle applicable in any degree to rural electric service?

PRINCIPLES OF REGULATION

The passing on to the public of the advantages of assured fuel supply at stable cost, of mass production, and of cheap and integrated transmission on the principle of territorial monopoly, can be assured only by adequate public service regulation of the giant power permittees and the segregated generating companies (wholesalers), of the transmitting companies, (common carriers) and of the segregated distributing systems. Under this head some far-reaching changes in current law and practice are essential.

Communities dependent for electric service, as Pennsylvania is, upon private investment and management, must rely upon public regulation for the availability and adequacy of service, for the prevention of discrimination, for the fairness of rates and, in general, for the realization of the broad social benefits to be made possible by general electrification. Such general electrification is a public function which cannot be accomplished without the exercise of the sovereign powers of the Commonwealth. It is the settled policy of Pennsylvania, practically fixed by the State Constitution, to entrust these sovereign powers to private corporations and depend upon their desire for gain as the mainspring of enterprise in furnishing electric service. The industry is expanding rapidly and must continue to do so if the people are to be adequately served. Therefore very large amounts of new capital must now and for a long period in the future be invested in electric service. There must be sufficient prospect of gain to attract this new capital and to keep on attracting it during the era of expansion. The terms upon which service may be had are less important than the question whether or not we can have the service at all. Therefore, and entirely aside from any constitutional or legal requirements, the first principle of regulation is to afford to

investors such reasonable opportunity for a fair return on the investment as will continue to attract new capital. The investor's controlling motive is in his prospective return, not in the method of computing it.

RATE BASE—PRESENT VALUE

Unfortunately the method of computation has generally been determined by legalistic instead of economic and administrative considerations. The prohibition against depriving any person of property without due process of law, laid upon the Federal Government by the fifth amendment of the Constitution of the United States, and upon the State Governments by the fourteenth amendment, has been construed by the Supreme Court of the United States to require the ascertainment, as of the time when the regulation is attacked, of the value of the property then used and useful in rendering the service, as a basis for determining whether any rate or charge for public service, fixed by public authority, effects a taking of property without due process of law (confiscation). Such a method of determining the "rate-base" is extremely difficult, slow, costly, uncertain, hypothetical, provocative of controversy in the making and unstable when made. It wastes in expenses and fees of attorneys and valuation engineers money which the consumers utimately pay. It wastes something far more important still—the time, energy and attention of managers, Public Service Commissioners and others which ought to be devoted to improving the service. It fosters misunderstanding and ill will. It should be replaced by a method easy, prompt, cheap, certain, factual and stable.

"PRUDENT INVESTMENT"

Such a method of fixing the rate-base is at hand as to future investments if the law permits its use. It measures the rate-base by the amount of money, as determined by accurate, prescribed and supervised accounting, which shall have been prudently invested after a fixed date, say January 1, 1926, in the enterprise, plus the agreed or determined value of the property then and continuously thereafter used and useful in it. Once this initial valuation were made the rate-base at any time thereafter could be read from the company's books. Upon this base there should be fixed from time to time such rates for service (varying somewhat with the degree of risk, general business conditions, etc.) as would attract new money in sufficient volume into

well managed enterprises, that is to say, enough to keep the stock slightly above par in the market.

It is not too much to say that the substitution of "prudent investment" for "present value" as the rate-base would go far toward making public utility regulation effective—a result vitally important to the public and to investors in public utilities because it is the only thinkable alternative to public ownership and operation. So long as the Supreme Court of the United States adheres to its present rulings this substitution cannot be imposed upon the companies against their will. It can, however, be accepted on their part by contract. It is so accepted as a required condition of all licenses from the Federal Government under the Federal Water Power Act of 1920, which has induced unprecedented investments in hydro-electric enterprises throughout the country.

"Prudent investment," therefore, is now the prevailing rule binding upon the Pennsylvania Public Service Commission and the companies as to the two great hydro-electric projects built and building in the State under that statute. Its acceptance should likewise be required by statute as a condition precedent to every new grant to a public service power company from the Commonwealth of any privilege or consent whatever, such as corporate charters, mergers, findings of public convenience and necessity for extensions, the exercise of the right of eminent domain, permits, etc. Pending the enactment of such legislation grants and consents within administrative discretion (such as the approval of new charters) should be withheld.

CONTROL OF SECURITY ISSUES

For the protection of investors and consumers alike, the par value of outstanding securities of a well managed electric company should, in theory, equal the rate-base. The Public Service Company Law, as originally drafted, gave the Public Service Commission power to regulate the issue of securities. This provision was stricken from the bill before its enactment. It should now be restored. The Federal Water Power Act requires licensees to submit to regulation by the State Public Utility Commissions of inter-state rates, service, and security issues, or in the absence thereof, to regulation of the same by the Federal Power Commission. The great Commonwealth of Pennsylvania ought to be able to stand alone and protect its own investors and consumers. It ought no longer to shirk its duty in this matter.

NEW STOCK—ISSUE PRICE

The normal price of the stock of a well managed and well regulated electric company may be considered to be par or a little higher. It frequently happens, however, that such stock commands a much higher price and that new capital is often raised, in these circumstances, by giving to the stockholders *pro rata* the right to subscribe at par for new stock. Such subscription rights often command substantial prices in the market. The new investor buys from the old investor the latter's subscription rights and then subscribes for and pays the company the par value of the new stock.

If the task of regulation has been properly performed the old stockholder has already enjoyed a reasonable opportunity to receive in dividends a fair return on his investment. All the money that the new investor is willing to spend for his new stock should go into the company's treasury for public service. Therefore the Public Service Commission, in approving proposed new issues of stock in an old company, should fix the price, at or above par, at which it is to be offered to the old stockholders, with provision for sale at auction or otherwise of any part of the new stock not taken by them. Such is the practice in Massachusetts (Con. Laws Ch. Sec. 19, as amended April 8, 1921, ch. 246, March 31, 1922 ch. 226) and it has produced good results.

CONTROL AND REFORMATION OF CONTRACTS OF LEASE, MANAGEMENT, ETC.

It sometimes happens that an operating public service company is handicapped by unconscionable burdens imposed by contracts of lease, management, etc. The Public Service Company Law subjects to regulation only operating companies. The doings and earnings of lessor companies which own but do not operate public service facilities cannot be controlled or looked into. In theory the rental paid to the lessor company has nothing to do with the present value of the property in service (the present rate-base). In theory, therefore, the Public Service Commission should be blind to the certain bankruptcy of the operating company that might be ground out between the upper millstone of a fair return on the rate-base and the lower millstone of the agreed rental; but in practice this could not be ignored without great harm to the service. It ought not to be ignored. The lessor company has dedicated its property to the public service no less than

the operating lessee. The public welfare requires that the two be equally subject to just regulation. It is settled law that contracts between two state agencies (a municipality and a public service company) may, in the public interest, be set aside by the State as the common master of both. The same principle should apply when both the State agents are companies holding property dedicated to public service, provided, of course, that confiscation of present property values does not result.

Contracts for management may also impose financial burdens unduly large and therefore detrimental to the public interest. They should be subject to control as to the amount of such expense by the Public Service Commission.

REWARDING EFFICIENCY

It is not the function of public utility regulation to reduce public service to a dead level of mediocrity by insuring profits for incompetent or unenterprising companies and by denying to exceptionally intelligent and efficient management a reward higher than the common level. If the service is exceptionally adequate and cheap in view of the circumstances the company should not be begrudged a high return on its rate-base. On the other hand, if the service is below standard for the circumstances, above all if it is non-existent, the company has no just claim to protection.

It is believed that the enactment of the proposals made in the foregoing part of this paper can, with proper regulation, bring about a real integration of electric service throughout the Commonwealth and thereby make available cheap power to all the territory that can be served under present economic and engineering conditions. No company should have power to prevent such service in any part of that territory. Unused rights of every kind, including charters, should be annulled promptly. Distribution systems operating small or antiquated generating systems at high cost should be required to avail themselves of the cheap power now to be brought within their reach, on pain of loss of their exclusive distribution rights in favor of a more enterprising privately owned or a publicly owned distribution system; but in taking such action against a company which has not in the past had access to a supply of cheap power the Public Service Commission should make equitable provision for amortizing the

obsolete plant and spreading the cost thereof over the rates for a series of years.

In short the single buried talent of the slothful steward should be taken from him and given to one who has ability to manage it.

ACCOUNTING

Accurate and revealing accounting should be the skeleton of rate regulation. The books should at all times show the amount of "prudent investment" after the initial date plus the value, as of that date, of property then and continuously thereafter used and useful. They should clearly exhibit costs incurred under promotion and construction contracts for rigid scrutiny by and the approval or disapproval of the Public Service Commission as a part of the rate-base.

The segregation of the costs (including both capital costs and operating costs) of construction, of transmission, and of distribution is essential to a clear understanding of the business. This should be required by the Public Service Commission without new legislation. It will be one of the results of the segregation of the corporate ownership of those three branches of the industry.

The output sold to each class of customers, the total amount received from each class, and the rate per kwh. charged each class, should also be shown.

It has been suggested that the Commission should have authority to require the letting of construction and supply contracts to the lowest responsible bidder and to authorize the rejection of any and all bids upon due cause shown. This proposal should be further investigated by the Giant Power Board.

THE GOAL OF RATE REGULATION

The initiative of The Public Service Commission in the matter of rate fixing should be freely used to attain ends which should be clearly formulated and kept constantly in view. The constitutional limitation in the Commission's power in this matter is the prohibition against a rate system that as a whole would be confiscatory. The general principle should also be accepted that, so far as consistent with the social ends in view, each of a few simple classes of service should bear its own cost. The principle of rewarding efficiency should also be kept in mind.

With these premises the Commission should bring about a great simplification of rates, because the business in question is public busi-

ness and must therefore be stated and reported in terms which the public can readily understand.

In the next place the Commission should strive to secure the realization of the great possibilities of general social economic betterment inherent in the integration of electric service over great areas. The chief of these are the decentralization of industry and population, and the invigorating and enriching of country life and family life. All artificial handicaps upon rural service, domestic consumers and small industrial users should be swept away. The Commission should proceed by cautious steps to reduce differences in rates to the lowest terms compatible with sound principles.

The economic principles of rate making should be determined and clearly formulated, such as, for example, the manner in which and the extent to which differences of rates should be based on differences between on-peak and off-peak loads.

The social advantages, if any, resulting from giving large industrial consumers great advantage in rates over small industrial consumers, for example, should be critically examined. The public interest requires that the electric industry should give the broadest economic service to the Commonwealth as a whole and receive sufficient profit to induce that result. Except as a means to that end the public is not greatly concerned that investors should be lured away from other industries into legal monopoly of the electric industry.

These aims of rate regulation should be broadly stated by statute as a guide to the Commission.

CONTROL BY COURTS

The Commission should be given the broadest powers consistent with due process of law as defined under constitutional provisions. Court review should be kept within these limits. The powers of the Interstate Commerce Commission should be taken as a model in this respect.

FEES TO PAY COST OF ADMINISTRATION

It has been suggested that the cost of administering the necessary control of the public service power business should be paid by fees charged upon the business. A tax or fee of one-hundredth of a mill per kwh. would now yield about $50,000 per year. This subject should be further investigated by the Giant Power Board.

APPENDICES

Appendix A

ANALYSIS OF PENNSYLVANIA PUBLIC UTILITIES

1. Analysis of Electric Power Utilities in the Commonwealth of Pennsylvania

By O. M. Rau

Index to Electric Power Companies
Operating in Pennsylvania

Key Index	*Name*	*Description*	*Counties (By No.) in which Co. operates.*
B- 1	Abington Electric Co.	Local Company	35
B- 2	Allaire Lt. & Pw. Co.	Local Company	4
(A)	ALLENTOWN & READING TRACTION CO.	Holding Company	
(B)	AMERICAN ELECTRIC POWER CO.	Holding Company	
(C)	AMERICAN GAS COMPANY	Holding Company	
(D)	AMERICAN WATER WKS. & EL. CO.	Holding Company	
B- 4	Annville & Palmyra E. Lt. Co.	Local Company	38
B- 3	Anthracite Power Co.	Controlled by G	40
A- 1	Arendtsville El. Lt. Plant	Local Company	1
A- 2	Aspinwall Mun. Plant	Local Company	2
B- 6	Bakertown Lt. Ht. & Pw. Co.	Local Company	
B- 5	Balley Mun. Plant	Local Company	6
A- 3	Bangor Electric Co.	Local Company	48
A- 4	Barnesboro Sprangler El. Lt. Co.	Local Company	11
B- 9	Bechtelville Mun. Plant	Local Company	6
A- 5	Bedford El. Lt. Ht. & Pw. Co.	Local Company	5
A- 6	Benton Hydro Elec. Co.	Local Company	19
B- 11	Berkshire Elec. Co.	Controlled by Q	6
B- 7	Berks-Lehigh Co.	Local Company	39- 6
B- 8	Berlin Mun. Plant	Local Company	56
A- 7	Bernville Lt. Ht. & Pw. Co.	Local Company	6
A- 8	Big Spring Elec. Co.	Local Company	21
A- 9	Birdsboro Elec. Co.	Local Company	6
B- 13	Black Lick L. H. & Pw. Co.	Local Company	11
	Blakeley Boro M. P.	Local Company	35
A- 10	Blue Mountain Elec. Co.	Local Company	6
A- 11	Boiling Spring E. L. & Water Co.	Local Company	21
B- 15	Bolivar Lt. Ht. & Pw. Co.	Local Company	32
A- 12	Boyertown Elec. Co.	Local Company	6-46
B- 20	Brackenridge Lt. & Pw. Co.	Local Company	1
A- 13	Bradford Electric Co.	Local Company	42

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A- 14	Brockway Lt. Ht. & Pw. Co.	Local Company	33
B- 17	Brownstone El. Lt. & Pw. Co.	Local Company	36
B- 19	Brown Twp. Lt. Ht. & Pw. Co.	Local Company	44
A- 15	Carlisle Gas & Water Co.	Local Company	21
B- 21	Catawissa Mun. Plant	Local Company	19
B- 22	Center Electric Co.	Local Company	14
A- 16	Chambersburg Mun. Plant	Local Company	28
B- 24	Chester County Lt. & Pw. Co.	Controlled by B	15
A- 17	Chester Valley Elec. Co.	Controlled by J	15
A- 18	Citizens Elec. Co.	Controlled by G	41
B- 28	Citizens Elec. Co. of Lewisburg	Local Company	60
B- 25	Citizens Electric Co. of Valley View	Local Company	54
B- 26	Citizens El. Lt. & Pw. Co. of Hughesville	Local Company	41
B- 74	Carpenter, Harley D.	Local Company	20
B- 29	Citizens Lt. Ht. & Pw. Co.	Controlled by L	56
A- 19	Citizens Lt. & Pw. Co.	Controlled by J	61
A- 20	Citizens Traction Co.	Controlled by J	61
B- 31	Clarendon El. Lt. & Pw. Co.	Local Company	62
B- 30	Clover Elec. Co.	Local Company	11
A- 21	Clymer Power Co.	Local Company	48
B- 37	Coalport Lt. Ht. & Pw. Co.	Local Company	17
B- 35	Concord Twp. Pw. Co.	Controlled by L	25
B- 33	Conemaugh Mun. Plant	Local Company	11
B- 39	Conestoga Valley Elec. Co.	Local Company	36
A- 22	Confluence Mun. Plant	Local Company	56
B- 38	Conneaut Lake E. L. & P. Co.	Local Company	20
(E)	CONSOLIDATED UTILITIES CO.	Holding Company	
B- 34	Coopersburg E. L. H. & P. Co.	Controlled by G	39
A- 23	Coraopolis Mun. Plant	Local Company	2
B- 36	Corry City Elec. Co.	Controlled by L	25
A- 24	Counties Gas & Electric Co.	Controlled by R	15-23-46
B- 40	Cresson Electric Lt. Co.	Local Company	11
A- 26	Cumberland Valley Lt. & Pw. Co.	Local Company	1-21-67
A- 27	Dalmatia Light Co.	Controlled by I	49
A- 28	Danville Mun. Plant	Local Company	47
A- 29	Deal Elec. Lt. & Pw. Plant	Local Company	5
B-174	Delta Elec. Co.	Local Company	67
A- 30	Delta Water Power Co.	Local Company	67
A- 31	Dunbar Elec. Co.	Local Company	26
A- 33	Duncannon Mun. Plant	Local Company	50
A- 34	Duquesne Light Co.	Controlled by S	1-4-2-10-65

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A- 36	Eagles Mere Lt. Co.	Local Company	41-57
B- 47	E. Greenville E. L. H. & P. Co.	Controlled by G	46
A- 38	E. Penn Elec. Co.	Controlled by F	22-54
A- 37	E. Penna. Gas & Elec. Co.	Controlled by C	9
A- 39	Eastern Pa. L. H. & Pw. Co.	Controlled by F	19-54
(F)	EASTERN PENNA. PW. & RAILWAYS CO.	Holding Company	
B- 45	Easton Mun. Plant	Local Company	48
A- 40	Ebensburg Lt. Ht & Pw. Co.	Local Company	11
A- 42	Edison Elec. Co. of Lancaster	Controlled by Q	36
A- 41	Edison Lt. & Pw. Co.	Controlled by H	67
(G)	ELECTRIC BOND AND SHARE CO.	Holding Company	
B- 52	Elwood City Mun. Plant	Local Company	37
A- 43	Emporium Mun. Plant	Local Company	12
A- 44	Ephrata Mun. Plant	Local Company	36
A- 46	Erie County Elec. Co.	Local Company	25
A- 45	Erie Lighting Co.	Controlled by L	25
A- 47	Etna Mun. Plant	Local Company	2
A- 48	Everett Lt. Ht. & Pw. Co.	Local Company	5
B- 54	Excelsior Elec. Lt. & Pw. Co.	Controlled by G	9-46
B- 55	Farmers Elec. Co. of Martic Twp.	Local Company	36
A- 49	Fawn Light & Power Co.	Local Company	67
A-144	Fayetteville E. L. & Pw. Co.	Controlled by D	28
B- 56	Fleetwood & Kutztown E. L. H. & Pw. Co.	Controlled by A	6
A- 50	Ford City Mun. Plant	Local Company	3
A- 51	French Creek Elec. Co.	Local Company	15
B- 59	Gallitzin Elec. Co.	Local Company	11
B- 57	Garland Mfg. Co.	Local Company	37
B- 58	Garrett E. L. H. & Pw. Co.	Local Company	56
(H)	GENERAL GAS & ELECTRIC COMPANY	Holding Company	
B- 60	Gettysburg Elec. Co.	Controlled by H	1
B- 61	Girard Mun. Plant	Local Company	25
B- 62	Glen Rock E. L. & Pw. Co.	Local Company	67
B- 63	Goldsboro Mun. Plant	Local Company	67
B- 66	Gratz Lt. & Pw. Co.	Local Company	22
B- 65	Greene Twp. Elec. Co.	Controlled by D	28
B- 64	Greencastle Lt. H. Fuel & Pw. Co.	Local Company	28
B- 67	Green Lane Lt. Ht. & Pw. Co.	Local Company	46
A- 52	Grove City Mun. Plant	Local Company	43
B- 73	Hamburg Gas & Elec. Co.	Local Company	6
B- 75	Hamilton Elec. Co.	Controlled by D	28

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A- 53	Hanover Power Co.	Controlled by L	67
B- 69	Harmony Elec. Co.	Local Company	1-10-4-37
A- 54	Harrisburg Lt. & Pw. Co.	Controlled by Q	22
B- 68	Harvey Lake Light Co.	Local Company	66-40
B- 70	Hastings Elec. Co.	Local Company	11
B- 71	Hatfield Mun. Plant	Local Company	46
A- 55	Heller Milling Company	Local Company	40
A- 56	Hershey Elec. Co.	Local Company	22
A- 57	Hoffman, Wm. I., Elec. Co.	Local Company	21
A- 59	Home Electric Co.	Controlled by D	53
A- 58	Home Elec. Lt. & Stm. Htg. Co.	Controlled by B	7-31
B- 78	Home Power Co.	Controlled by L	25
A- 60	Honesdale Con. Lt. Ht. & Pw. Co.	Controlled by G	64
B- 79	Houtzdale E. L. H. & Pw. Co.	Controlled by G	17
A- 61	Hummelstown Water & Pw. Co.	Local Company	22
A- 62	Hyndman El. Lt. Ht. & Pw. Co.	Controlled by D	5
B- 81	Intercourse Elec. Co.	Controlled by L	36
B- 82	Jackson Lt. Ht. & Pw. Co.	Local Company	11
A- 63	Jersey Shore Elec. Co.	Controlled by G	41
(I)	JUNIATA PUBLIC SERVICE CORP.	Holding Company	
A- 64	Juniata Public Ser. Co.	Controlled by I	22-34-50
A- 65	Keystone Power Corporation	Controlled by D	14-18-24-42-53
B- 84	Kurtztown Mun. Plant	Local Company	6
A- 68	Lackawanna & Wyo. V. Pw. Co.	Controlled by G	35-40
A- 69	Lancaster El. L. H. & Pw. Co.	Controlled by Q	36
B- 85	Langhorne El. L. & Pw. Co.	Local Company	9
A- 70	Lansdale Mun. Plant	Local Company	46
B- 87	Lehighton El. Lt. & Pw. Co.	Controlled by G	13
B- 88	Lilly Lt. Ht. & Pw. Co.	Local Company	11
A- 71	Lock Haven Elec. Co.	Controlled by G	18
A- 72	Logan Lt. Ht. & Pw. Co.	Local Company	11
B- 89	Lower Chanceford El. L. H. & Pw. Co.	Local Company	67
B- 91	Ludlow Gas & Elec. Co.	Local Company	42
A- 73	Luzerne County Gas & Elec. Co.	Controlled by C	40
A- 74	Lycoming Edison Co.	Controlled by G	41
A- 75	McAllisterville Mun. Plant	Local Company	34
B- 93	Macungie El. Lt. H. & Pw. Co.	Controlled by G	39
B- 94	Marklesburg Lt. & Pw. Co.	Local Company	31
B- 92	Mauch Chunk Ht. Pw. & El. Lt. Co.	Controlled by G	13

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A- 76	Media Mun. Plant	Local Company	23
B- 96	Meadville Mun. Plant	Local Company	20
A- 81	Mercerbg, Lemasters & Markes, El. Co.	Local Company	28
A- 80	Mercer County L. H. & Pw. Co.	Local Company	43
A- 77	Metropolitan Edison Co.	Controlled by H	6-15-36-38-46
A- 82	Meyersdale El. Lt. Ht. & Pw. Co.	Local Company	56
B- 98	Middleburg L. H. & Pw. Co.	Controlled by I	55
B-101	Middleton Mun. Plant	Local Company	22
B- 99	Mifflinburg Mun. Plant	Local Company	60
B-100	Milville El. Lt. Co.	Controlled by G	19
A- 83	Montgomery & Muncy E. L. H. & Pw. Co.	Local Company	41
A- 84	Montoursville El. Lt. Co.	Local Company	41
B-103	Moscow Elec. Co.	Local Company	35
A- 85	Mt. Pocono Lt. & Imp. Co.	Local Company	45
(J)	MUNICIPAL SERVICE COMPANY	Holding Company	
A- 86	Naomi Pines Elec. Co.	Local Company	45
A- 87	Natrona Lt. & Pw. Co.	Local Company	2
B-108	New Castle Elec. Co.	Controlled by G	37
B-109	New Freedom Mun. Plant	Local Company	67
B-104	New Hope Elec. Co.	Controlled by C	9
B-106	New Kingston E. L. H. & Pw. Co.	Local Company	21
B-105	Newmanstown E. L. & Pw. Co.	Local Company	38
B-107	New Wilmington M. Plant	Local Company	37
B-111	Niantic El. Lt. & Pw. Co.	Local Company	6-46
B-110	Nicholson Lt. Ht. & Pw. Co.	Local Company	66
B-112	Norristown Mun. Plant	Local Company	46
A- 88	North Penn Power Co.	Local Company	8-59
A- 90	Olyphant Mun. Plant	Local Company	35
A- 91	Orangeville E. L. & Pw. Co.	Local Company	19
A- 92	Orbisonia Lt. Co.	Local Company	31
B-113	Orrtanna El. Lt. & Pw. Co.	Local Company	1
A- 93	Oxford Electric Co.	Local Company	15
B-117	Paint Elec. Co.	Local Company	56
B-116	Palm El. Lt. & Pw. Co.	Controlled by G	46
B-114	Palmerton Lt. Co.	Local Company	13
B-115	Panther Valley Elec. Co.	Controlled by G	13-54
A- 94	Paupack Elec. Co.	Controlled by G	64
A- 95	Pecksville Mun. Plant	Local Company	35
(M)	PENN CENTRAL LT. & PW. Co.	Holding Company	
A- 66	Penn Central Lt. & Pw. Co.	Controlled by M	11-44-7-31

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A-119	Pennsburg Mun. Plant	Local Company	46
B-119	Penn Twp. Power Co.	Local Company	65
A- 98	Penns Creek Hydro Elec. Co.	Local Company	60
(L)	PENNSYLVANIA ELECTRIC COMPANY	Holding Company	
A-108	Pennsylvania Ed. Co.	Controlled by F	45
(K)	PENNSYLVANIA-OHIO PW. & LT. CO.	Holding Company	
A-100	Penn Public Service Corp.	Controlled by L	11-14-16-17-20-25-32-33-56-61-62-65
A-111	Pennsylvania Pw. Co.	Controlled by G	37- 4
A-112	Penna. Pw. & Lt. Co.	Controlled by G	9-13-18-19-39-40-41-45-46-47-48-49-54-55-60-64
(N)	PENNSYLVANIA WATER & PW. CO.	Holding Company	
A-118	Penna. W. & Pw. Co.	Controlled by N	67
B-118	Pequea Elec. Co.	Local Company	36
A-120	Perkasie Mun. Plant	Local Company	9
(O)	PHILADELPHIA ELECTRIC COMPANY	Holding Company	
A-123	Philadelphia Elec. Co.	Controlled by O	51-23-46
A-124	Philadelphia Hydro Elec. Co.	Local Company	51
A-121	Philadelphia Sub. Gas & Elec. Co.	Controlled by C	9-15-46
A-125	Phoenix Water Pw. Co.	Local Company	15
B-128	Pike County Lt. & Pw. Co.	Local Company	52
B-126	Pine Grove El. L. H. & Pw. Co.	Controlled by F	54
B-127	Pioneer Elec. Co.	Local Company	35
A-126	Pitcairn Mun. Plant	Local Company	2
B-129	Portage Lt. & Pw. Co.	Local Company	11
B-131	Prompton Electric Co.	Local Company	64
B-130	Prospect Rock El. Lt. H. & Pw. Co.	Local Company	40
A-127	Quakertown Mun. Plant	Local Company	9
B-132	Railroad El. Lt. & Pw. Co.	Local Company	67
A-128	Raystown Water Pw. Co.	Local Company	7
B-133	Red Hill El. Lt. & Pw. Co.	Local Company	46
A-130	Renovo Edison L. H. & Pw. Co.	Local Company	18
(P)	REPUBLIC RAILWAY & LIGHT CO.	Holding Company	
B-134	Ringtown L. H. & Pw. Co.	Controlled by G	54
B-136	Rockingham L. H. & Pw. Co.	Local Company	56
B-135	Rockwood El. Co.	Local Company	56
B-137	Royalton Mun. Plant	Local Company	22
A-140	St. Claire Mun. Plant	Local Company	2
A-131	Sayre Electric Co.	Controlled by H	59-8

Key Index	Name	Description	Counties (By No.) in which Co. operates.
A-132	Saylorsburg Lt. & Pw. Co.	Local Company	45
B-138	Schuylkill Elec. Co.	Controlled by G	19-54
A-133	Schuylkill Haven M. Plant	Local Company	54
A-134	Scranton Elec. Co.	Controlled by G	35-40-58-64
B-140	Scrap Level El. Co.	Local Company	11
B-141	Sewickley Twp. Pw. Co.	Local Company	65
A-136	Sharpsburg Mun. Plant	Local Company	2
B-142	Sheffield El. Lt. & Pw. Co.	Local Company	62
B-143	Shenango Valley El. Lt. Co.	Controlled by P	43
A-137	Shermans Valley Lt. Ht. & Pw. Co.	Local Company	50
A-138	Shippensburg C. & El. Co.	Local Company	28
A-139	Solar Electric Co.	Local Company	33
B-144	Sommerhill Mun. Plant	Local Company	11
B-146	Standard Pub. Ser. Co.	Controlled by M	7
B-145	Stoufferstown El. Co.	Local Company	28
A-141	Sullivan County Elec. Co.	Local Company	8-57-66
A-142	Susquehanna Lt. & Pw. Co.	Controlled by L	58
A-143	Tarentum Mun. Plant	Local Company	2
B-147	Tatamy L. H. & Pw. Co.	Local Company	48
A-145	Titusville Lt. & Pw. Co.	Local Company	20-61
A-146	Titusville Mun. Plant	Local Company	20
B-149	Topton Electric Lt. & Pw. Co.	Controlled by G	6
A-147	Towanda Gas & Elec. Co.	Local Company	8
B-150	Tri County Elec. Co.	Local Company	36
A-148	Troy El. Lt. Ht. & Pw. Co.	Local Company	8
A-149	Tunkhannock Elec. Co.	Local Company	66
B-154	Union City Elec. Co.	Controlled by L	25
A-151	United Electric Co.	Controlled by E	21-50-67
(Q)	UNITED GAS & ELECTRIC CORP.	Holding Company	
(R)	UNITED GAS IMPROVEMENT CO.	Holding Company	
B-151	United Lt. Ht. & Pw. Co.	Local Company	56
B-152	United Lighting Co.	Controlled by E	20-25
(S)	UNITED RAILWAY INVESTMENT CO.	Holding Company	
A-150	United Electric Light Co.	Local Company	1-2
A-153	Valley Elec. Ser. Co.	Local Company	49
A-152	Varden & Lake Ariel L. H. & Pw. Co.	Local Company	64
A-154	Vinton Colliery Co.	Local Company	11
B-159	Wampum Mun. Plant	Local Company	37
B-156	Waterford Elec. Lt. Co.	Local Company	25
C-71	Waterford Elec. Co.	Local Company	25

Key Index	Name	Description	Counties (By No.) in which Co. operates.
B-177	Waterford Twp. El. L. H. & P. Co.	Local Company	25
A-155	Watsontown Mun. Plant	Local Company	49
A-156	Waynesboro Elec. Co.	Controlled by D	28
B-155	Wayne Twp. Power Co.	Controlled by L	25
B-158	Wayside Elec. Co.	Local Company	56
A-157	Weatherly Mun. Plant	Local Company	13
B-162	Weimer El. Lt. & Pw. Co.	Controlled by H	38
B-160	Weisenberg El. Lt. & Pw. Co.	Local Company	39-6
A-158	Wellsboro Elec. Co.	Local Company	59
B-161	Wellersburg Elec. Co.	Local Company	56
A-159	West Penn Power Co.	Controlled by D	1- 3-10-16-26-30-63-65
A-168	White Haven El. Ill. Plant	Local Company	40
B-164	White Oak Lt Ht. & Pw. Co.	Local Company	56
B-165	Windber Elec. Co.	Local Company	56
B-167	Winola Elec. Co.	Local Company	46
B-168	Wrightsville Lt. & Pw. Co.	Local Company	67
A-169	Yeagertown Water Power Co.	Controlled by M	44
A-170	York Haven Water & Pw. Co.	Controlled by H	22-36-67
B-171	Zelienople Lt. & Pw. Co.	Controlled by P	10
B-170	Zelienople Mun. Plant	Local Company	10

POPULATION TO WHOM SERVICE IS AVAILABLE

By Counties

County No.	County Name	Incorporated Places No.	Incorporated Places Population	Towns, Villages, etc. No.	Towns, Villages, etc. Population	Total Population
1.	Adams	11	11,638	8	1,286	12,924
2.	Allegheny	72	990,418	53	51,892	1,042,310
3.	Armstrong	10	25,759	9	2,500	28,259
4.	Beaver	22	74,746	5	3,149	77,895
5.	Bedford	3	5,196	1	50	51,246
6.	Berks	21	137,785	48	11,210	148,995
7.	Blair	9	108,211	2	800	116,211
8.	Bradford	9	22,903	5	735	23,638
9.	Bucks	18	30,870	4	945	31,815
10.	Butler	5	27,950	7	5,480	33,430
11.	Cambria	29	131,955	25	26,726	158,681
12.	Cameron	1	3,036			3,036
13.	Carbon	10	37,868	1	521	38,389
14.	Centre	10	13,373	21	5,892	19,265
15.	Chester	14	55,368	15	4,683	61,260
16.	Clarion	4	5,976	1	659	6,635
17.	Clearfield	18	37,841	28	12,377	50,218
18.	Clinton	6	19,186	3	1,500	20,686

County No.	County Name	Incorporated Places No.	Incorporated Places Population	Towns, Villages, etc. No.	Towns, Villages, etc. Population	Total Population
19.	Columbia	9	27,085	1	600	27,685
20.	Crawford	11	43,450	5	826	44,276
21.	Cumberland	12	30,895			30,895
22.	Dauphin	15	115,914	13	5,230	120,394
23.	Delaware	24	115,164	1	164	155,328
24.	Elk	3	18,404	5	2,712	21,116
25.	Erie	14	115,448	8	1,916	117,364
26.	Fayette	16	55,688	33	20,819	76,507
27.	Forest					
28.	Franklin	5	27,042	12	4,144	31,186
29.	Fulton					
30.	Greene	6	5,821	1	600	6,421
31.	Huntingdon	9	15,091	2	350	15,441
32.	Indiana	9	19,293	26	19,380	38,673
33.	Jefferson	7	24,962	11	5,680	44,342
34.	Juniata	4	2,912	1	536	3,448
35.	Lackawanna	21	264,193	1	3,915	268,108
36.	Lancaster	16	88,825	64	14,051	102,876
37.	Lawrence	6	57,092	2	854	57,946
38.	Lebanon	5	32,095	25	10,236	43,331
39.	Lehigh	10	96,766	7	1,550	98,316
40.	Luzerne	38	211,783	2	350	212,133
41.	Lycoming	9	55,302	3	733	56,035
42.	McKean	4	25,870	2	2,300	28,170
43.	Mercer	13	64,644			64,644
44.	Mifflin	4	13,494	6	9,236	22,730
45.	Monroe	1	5,278	5	4,105	9,383
46.	Montgomery	24	98,714	16	6,644	105,358
47.	Montour	1	6,952			6,952
48.	Northampton	30	184,226	12	4,000	188,226
49.	Northumberland	13	184,226	1	500	184,726
50.	Perry	5	6,329	3	1,262	7,591
51.	Philadelphia	1	1,823,779			1,823,779
52.	Pike	1	1,535			1,535
53.	Potter	1	2,836			2,836
54.	Schuylkill	28	142,722	4	4,575	147,297
55.	Snyder	3	3,446	6	1,904	5,350
56.	Somerset	17	28,057	26	8,784	36,841
57	Sullivan	2	948	7	3,350	4,298
58.	Susquehanna	8	15,925			15,925
59.	Tioga	4	7,462	3	5,250	12,712
60.	Union	3	5,408			5,408
61.	Venango	5	33,739	1	1,000	34,739
62.	Warren	2	15,200	3	2,450	17,650
63.	Washington	26	101,334	23	13,380	114,714
64.	Wayne	5	5,528	5	2,595	8,123
65.	Westmoreland	31	99,266	48	51,743	151,009
66.	Wyoming	2	2,578			2,578
67.	York	30	80,584			80,584
	TOTAL	785	6,132,912	630	407,529	6,540,441
	STATE (All Counties)	1,212	6,187,784	7,562	1,622,233	8,720,017

NOTE: Estimated population not in cities, boroughs, towns or villages, etc. 910,000.

INDEX TO PRIME POWER SOURCES IN PENNSYLVANIA
ELECTRIC POWER UTILITIES

No.	Name of Local Company	Letter	Name of Holding Company	Locality of Plant: Town	Locality of Plant: County	Kind	Kw. Capacity
A- 1	Arendtsville El. Lt. Plant			Arendtsville	Adams	Hyd. & Stm.	27
A- 2	Aspinwall Municipal Plant			Aspinwall	Allegheny	Steam	1,000
A- 3	Bangor Electric Co.			Bangor	Northampton	Steam	750
A- 4	Barnesboro-Sprangler El. Lt. Co.			Barnesboro	Cambria	Steam	2,600
A- 5	Bedford El. Lt., Ht. & Pw. Co.			Bedford	Bedford	Nat. Gas Eng.	400
A- 6	Benton Hydro-El. Co.			Benton	Columbia	Hyd-Oil Eng.	50
A- 7	Bernville Lt., Ht. & Pw. Co.			Bernville	Berks	Hydro-Elec.	85
A- 8	Big Spring Elec. Co.			Newville	Cumberland	Stm. & Hyd.	210
A- 9	Birdsboro Elec. Co.			Birdsboro	Berks	Hydro-Elec.	75
A- 10	Blue Mountain El. Co.			Bethel	Berks	Hydro-Elec.	25
A- 12	Boyertown Elec. Co.			Boyertown	Berks	Steam	300
A- 13	Bradford Elec. Co.			Bradford	McKean	Nat. Gas. Eng.	1,140
A- 14	Brockway Lt., Ht. & Pw. Co.			Brockwayville	Jefferson	Steam	300
A- 15	Carlisle Gas & Water Co.			Carlisle	Cumberland	Stm. & Hyd.	3.550
A- 16	Chambersburg Mun. Plant			Chambersburg	Franklin	Steam	2,500
A- 17	Chester Valley Elec. Co.	M	Penn Central Lt. & Pw. Co.	Coatesville	Chester	Steam	3.000
A- 18	Citizens Electric Co.	G	Electric Bond & Share Co.	Williamsport	Lycoming	Steam	1,342
A- 19	Citizens Lt. & Pw. Co.	J	Municipal Service Co.	Franklin	Venango	Nat. Gas.	900
A- 20	Citizens Traction Co.	J	Municipal Service Co.	Oil City	Venango	....	....
A- 21	Clymer Power Co.			Raubsville	Northampton	Hydro-Elec.	750
A- 22	Confluence Mun. Plant			Confluence	Somerset	Steam	60
A- 23	Coraopolis Mun. Plant			Coraopolis	Allegheny	Nat. Gas	820
A- 24	Counties Gas & Elec. Co.	R	United Gas Improvement Co.	Wayne	Delaware	Steam	1,630
A- 25	Counties Gas & Elec. Co.	R	United Gas Improvement Co.	Norristown	Montgomery	Steam	20,000
A- 26	Cumberland Valley Lt. & Pw. Co.			Williams Grove	Cumberland	Hydro-Elec.	75
A- 27	Dalmatia Lt. Co.			Dalmatia	Northumberland	Steam	60
A- 28	Danville Mun. Plant			Danville	Montour	Steam	150
A- 29	Deal Elec. Lt. & Pw. Co.			....	Bedford	Stm. & Hyd.	110
A- 30	Delta Water Pw. Co.			Castle Fin	York	Hydro-Elec.	165
A- 31	Dunbar Elec. Co.			Dunbar	Fayette	Steam	450
A- 33	Duncannon Mun. Plant			Duncannon	Perry	Steam	100
A- 34	Duquesne Light Co.	S	United Ry. Inv. Co.	Pittsburgh & Rankin	Allegheny	Steam	25,400
A- 35	Duquesne Light Co.	S	United Ry. Inv. Co.	Brunot Is. & Colfax	Allegheny	Steam	240,000

A- 36	Eagles Mere Lt. Co.			Muncy Valley	Sullivan	Hydro-Elec.	240
A- 37	East Pa. Gas & Elec. Co.	C	American Gas Company	Bristol	Bucks	Steam	175
A- 38	East Penn Elec. Co.	F	Eastern Pa. Pw. & Ry Co.	Williamstown	Dauphin	Steam	2,650
A- 39	Eastern Pa. Lt., Ht. & Pw. Co.	F	Eastern Pa. Pw. & Ry Co.	Palo Alto	Schuylkill	Steam	10,200
A- 40	Ebensburg Lt. Ht. & Pw. Co.			Ebensburg	Cambria	Steam	630
A- 41	Edison Light & Pw. Co.	H	General Gas & Elec. Co.	York	York	Steam	8,525
A- 42	Edison Elec. Co. of Lancaster	Q	United Gas & Elec. Co.	Lancaser	Lancaster	Steam	4,000
A- 43	Emporium Mun. Plant			Emporium	Cameron	Nat. Gas	375
A- 44	Ephrata Mun. Plant				Lancaster	Steam	800
A- 45	Erie Lighting Co.	L	Pennsylvania Electric Co.	Erie	Erie		
A- 46	Erie County Elec. Co.			Erie	Erie	Steam	22,500
A- 47	Etna Mun. Plant			Etna	Allegheny	Steam	
A- 48	Everett Lt., Ht. & Pw. Co.			Everett	Bedford	Steam	700
A- 49	Fawn Light & Pw. Co.			Fawn Grove	York	Hydro-Elec.	50
A- 50	Ford City Mun. Plant			Ford City	Armstrong	Nat. Gas.	
A- 51	French Creek Elec. Co.			St. Peters	Chester	Hydro-Elec.	18
A- 52	Grove City Mun. Plant			Grove City	Mercer	Oil & Gas	525
A- 53	Hanover Power Co.	L	Pennsylvania Electric Co.	Hanover	York	Steam	4,000
A- 54	Harrisburg Lt. & Pw. Co.	Q	United Gas & Elec. Co.	Harrisburg	Dauphin	Steam	23,195
A- 55	Heller Milling Co.			Wapwallopen	Luzerne	Hydro-Elec.	27½
A- 56	Hershey Electric Co.			Hershey	Dauphin	Steam & Oil	5,420
A- 57	Wm. I. Hoffman El. Co.			Lisburn	Cumberland	Hydro-Elec.	37½
A- 58	Home El. Lt. & Stm. Htg. Co.	B	American Elec. Pw. Co.	Tyrone	Blair	Steam	1,000
A- 59	Home Electric Co.	D	American Wat. Wks. & El. Co.	Coudersport	Potter	Gas Eng.	437
A- 60	Honesdale Con. Lt. Ht. & Pw. Co.	G	Electric Bond & Share Co.	Honesdale	Wayne	Steam	800
A- 61	Hummelstown Water & Pw. Co.			Hummelstown	Dauphin	Hydro-Elec.	150
A- 62	Hyndman Elec. Lt. Ht. & Pw. Co.	D	American Wat. Wks. & El. Co.	Hyndman	Bedford	Hyd. & Stm.	115
A- 63	Jersey Shore Elec. Co.	G	Electric Bond & Share Co.	Jersey Shore	Lycoming	Steam	1,205
A- 64	Juniata Pub. Ser. Co.	J	Juniata Pub. Ser. Corp.	Millersburg	Dauphin	Steam	1,750
A- 65	Keystone Power Co.	D	American Wat. Wks. & El. Co.	Bellefonte & Millersburg	Center	Steam & Hyd.	3,565
A- 66	Keystone Power Corp.	D	American Wat. Wks. & El. Co.	Ridgway	Elk	Steam	15,000
A- 67	Keystone Power Co.	D	American Wat. Wks. & El. Co.	Kane	McKean	Gas	1,225
A- 68	Lac'aw'a & Wyom'g Val. Pw. Co.	G	Electric Bond & Share Co.	Scranton	Lackawanna	Steam	9,265
A- 69	Lancaster El. Lt., Ht., & Pw. Co.	Q	United Gas & Elec. Co.	Rock Hill	Lancaster	Hydro-Elec.	300
A- 70	Lansdale Mun. Plant			Lansdale	Montgomery	Steam	1,500
A- 71	Lock Haven Elec. Co.	G	Electric Bond & Share Co.	Lock Haven	Clinton	Steam	5,000
A- 72	Logan Lt., Ht. & Pw. Co.			Beaverdale	Cambria	Steam	200
A- 73	Luzerne Co. Gas. & El. Co.	C	American Gas Company	Plymouth	Luzerne	Steam	22,500
A- 74	Lycoming Ed. Co.	G	Electric Bond & Share Co.	Williamsport	Lycoming	Steam	11,900
A- 75	McAlisterville Mun. Plant			McAlisterville	Juniata	Gasoline	3
A- 76	Media Mun. Plant			Media	Delaware	Steam	125

INDEX TO PRIME POWER SOURCES IN PENNSYLVANIA: ELECTRIC POWER UTILITIES—Cont'd

No.	Name of Local Company	Letter	Name of Holding Company	Locality of Plant: Town	Locality of Plant: County	Kind	Kw. Capacity
A- 77	Metropolitan Edison Co.	H	General Gas & Elec. Co.	Lebanon	Lebanon	Steam	2,000
A- 78	Metropolitan Edison Co.	H	General Gas & Elec. Co.	W. Reading	Berks	Steam	39,000
A- 79	Metropolitan Edison Co.	H	General Gas & Elec. Co.	Klappenthal	Berks	Hydro-Elec.	500
A- 80	Mercer County Lt. Ht. & Pw. Co.			Greenville	Mercer	Steam	2,500
A- 81	Mercersburg-Lehmaster & Marks Elec. Co.			Markes	Franklin	Hyd. & Oil	150
A- 82	Meyersdale El. Lt., Ht. & Pw. Co.			Meyersdale	Somerset	Steam	1,170
A- 83	Montgomery & Muncy El. Lt., Ht. & Pw. Co.			Montgomery	Lycoming	Steam	1,500
A- 84	Montoursville El. Lt. Co.			Montoursville	Lycoming	Steam	380
A- 85	Mt. Pocono Lt. & Imp. Co.			Mt. Pocono	Monroe	Hydro. & Oil	68
A- 86	Naomi Pines Elec. Co.			Pocono Pines	Monroe	Hydro-Elec.	60
A- 87	Natrona Lt. & Pw. Co.			Natrona	Allegheny	Steam	6,700
A- 88	North Penn Power Co.			Blossburg & Mansfield	Tioga	Steam	910
A- 89	North Penn Power Co.			Troy & Canton	Bradford	Steam	325
A- 90	Olyphant Mun. Plant			Olyphant	Lackawanna	Steam	450
A- 91	Orangeville El. Lt. & Pw. Co.			Orangeville	Columbia	Steam	75
A- 92	Orbisonia Lt. Co.			Orbisonia	Huntingdon	Hyd. & Stm.	37
A- 93	Oxford Electric Co.			Oxford	Chester	Steam	200
A- 94	Paupack Elec. Co.	G	Electric Bond & Share Co.	Hawley	Wayne	Hydro-Elec.	350
A- 95	Pecksville Mun. Plant			Blakely	Lackawanna	Steam	475
A- 96	Penn Central Lt. & Pw. Co.	M	Penn Central Lt. & Pw. Co.	Warrior Ridge	Huntingdon	Stm. & Hydro	8,500
A- 97	Penn Central Lt. & Pw. Co.	M	Penn Central Lt. & Pw. Co.	Williamsburg	Blair	Steam	17,000
A- 98	Penns Creek Hydro-El. Co.			New Berlin	Union	Hyd-Oil Eng.	125
A- 99	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Rockwood	Somerset	Steam	8,500
A-100	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Warren	Warren	Steam	6,000
A-101	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Seward	Westmoreland	Steam	50,000
A-102	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Punxsutawney	Jefferson	Steam	1,000
A-103	Penn Public Service Corp.	L	Pennsylvania Electric Co.	DuBois	Clearfield	Steam	2,350
A-104	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Clearfield	Clearfield	Steam	600
A-105	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Erie	Erie	Steam	24,500
A-106	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Phillipsburg	Centre	Steam	11,000
A-107	Penn Public Service Corp.	L	Pennsylvania Electric Co.	Johnstown	Cambria	Steam	11,600
A-108	Pennsylvania Edison Co.	F	Eastern Pa. Pw. & Ry. Co.	Stroudsburg	Monroe	Hydro-Elec.	785

A-109	Pennsylvania Edison Co.	F	Eastern Pa. Rw. & Ry. Co.	Easton	Northampton	Steam & Hyd.	36,000
A-110	Pennsylvania Edison Co.	F	Eastern Pa. Rw. & Ry. Co.	Columbia, N. J.		Hydro-Elec.	270
A-111	Pennsylvania Power Co.	P	Republic Ry. & Lt. Co.	Ellwood City	Lawrence	Hydro-Elec.	1,250
A-112	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.	Harwood Mines	Luzerne	Steam	41,500
A-113	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.	Wilkes-Barre	Luzerne	Steam	14,000
A-114	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.	Sel'nsgrove	Snyder	Hydro-Elec.	250
A-115	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.	Hauto	Carbon	Steam	50,000
A-116	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.		Northumberland	Steam	8,325
A-117	Pennsylvania Pw. & Lt. Co.	G	Electric Bond & Share Co.	Bloomsburg	Columbia	Hydro-Elec.	200
A-118	Pennsylvania Water & Pw. Co.	N	Pennsylvania Wat. & Pw. Co.	Holtwood		Hydro-Elec.	83,500
A-119	Pennsburg Mun. Plant			Pennsburg	Montgomery	Steam	525
A-120	Perkasie Mun. Plant			Perkasie	Bucks	Steam	460
A-121	Philadelphia Sub. Gas & El. Co.	C	American Gas Co.	Cromby	Chester	Steam & Hyd.	20,350
A-122	Philadelphia Sub. Gas & El. Co.	C	American Gas Co.	West Chester	Chester	Steam	860
A-123	Philadelphia Electric Co.	O	Philadelphia Electric Co.	Philadelphia	Philadelphia	Steam	336,230
A-124	Philadelphia Hydro El. Co.			Philadelphia	Philadelphia	Hydro-Elec.	1,600
A-125	Phoenix Water Pw. Co.			Phoenixville	Montgomery	Hydro-Elec.	1,095
A-126	Pitcairn Mun. Plant			Pitcairn	Allegheny	Gas	600
A-127	Quakertown Mun. Plant			Quakertown	Bucks	Steam	1,000
A-128	Raystown Water Pw. Co.			Covedale	Blair	Steam	1,750
A-129	Raystown Water Pw. Co.			Raystown Br.	Huntingdon	Hydro-Elec.	2,100
A-130	Renovo Edison Lt., Ht. & Pw. Co.			Renovo	Clinton	Steam	800
A-131	Sayre Elec. Co.	H	General Gas & Elec. Co.	Sayre	Bradford	Steam	1,650
A-132	Saylorsburg Lt. & Pw. Co.			Saylorsburg	Monroe	Hydro-Elec	45
A-133	Schuylkill Haven Mun. Plant			Schuylkillhaven	Schuylkill	Steam	725
A-134	Scranton Elec. Co.	G	Electric Bond & Share Co.	Pittston	Luzerne	Steam	1,800
A-135	Scranton Elec. Co.	G	Electric Bond & Share Co.	Scranton	Lackawanna	Steam	47,200
A-136	Sharpsburg Mun. Plant			Sharpsburg	Allegheny	Steam	1,350
A-137	Shermans Valley Lt., Ht. & Pw. Co.			Loysville	Perry	Hydro-Elec.	90
A-138	Shippensburg, Gas & Elec. Co.			Shippensburg	Franklin	Steam & Hyd.	1,245
A-139	Solar Electric Co.			Brookville	Jefferson	Nat. Gas	561
A-140	St. Claire Mun. Plant			St. Claire	Allegheny	Steam	260
A-141	Sullivan Co. Elec. Co.			Dushore	Sullivan	Steam	450
A-142	Susquehanna Lt. & Pw. Co.	L	Pennsylvania Elec. Co.	Oakland	Susquehanna	Hyd. & Stm.	1,900
A-143	Tarentum Mun. Plant			Tarentum	Allegheny	Steam	1,500
A-144	Fayetteville El. Lt. & Pw. Co.	D	American Wat. Wks. & El. Co.	Fayetteville	Franklin	Hydro-Elec.	20
A-145	Titusville Lt. & Pw. Co.			Titusville	Crawford	Nat. Gas & Gas Eng.	935
A-146	Titusville Mun. Plant			Titusville	Crawford	Steam	150
A-147	Towanda Gas & El. Co.			Towanda	Bradford	Steam	600
A-148	Troy Elec. Lt., Ht. & Pw. Co.			Troy	Bradford	Steam	110
A-149	Tunkhannock Elec. Co.				Wyoming	Hyd. & Stm.	300
A-150	United Elec. Co.			Wilmerding	Allegheny	Gas	290

INDEX TO PRIME POWER SOURCES IN PENNSYLVANIA: ELECTRIC POWER UTILITIES—Cont'd

No.	Name of Local Company	Letter	Name of Holding Company	Locality of Plant: Town	Locality of Plant: County	Kind	Kw. Capacity
A-151	United Elec. Co.			Lemoyne	Cumberland	Steam	4,600
A-152	Varden & Lake Ariel			Varden	Wayne	Hydro-Elec.	125
A-153	Valley Elec. Ser. Co.			Herndon	Northumberland	Steam	50
A-154	Vinton Colliery Co.			Vintondale	Cambria	Steam	1,750
A-155	Watsontown Mun. Plant			Watsontown	Northumberland	Steam	85
A-156	Waynesboro Elec. Co.	D	American Wat. Wks. & El. Co.	Waynesboro	Franklin	Steam	500
A-157	Weatherly Municipal Plant			Weatherly	Carbon	Steam	400
A-158	Wellsboro Elec. Co.			Wellsboro	Tioga	Steam	1,275
A-159	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Springdale	Allegheny	Steam	42,000
A-160	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Windsor, W. Va.	Not in Pa.	Steam	30,000
A-161	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Connellsville	Fayette	Steam	56,500
A-162	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Ohiopyle	Fayette	Hydro-Elec.	60
A-163	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Butler	Butler	Steam	1,080
A-164	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Clarion & New		Stm. & Gas	200
				Bethlehem	Clarion	Hyd. & Gas	470
A-165	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Waynesburg	Greene	Gas	500
A-166	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Washington	Washington	Steam	900
A-167	West Penn Power Co.	D	American Wat. Wks. & El. Co.	Kittanning	Armstrong	Gas	100
A-168	White Haven El. Ill. Plant			White Haven	Luzerne	Hydro-Elec.	325
A-169	Yeagerstown Water Pw. Co.	M	Penn Central Lt. & Pw. Co.	Yeagerstown	Mifflin	Hydro-Elec.	300
A-170	York Haven Water & Pw. Co.	H	General Gas & Elec. Co.	York Haven	York	Hydro-Elec.	15,000

TOTALS:

Note: Including standby capacity and plants not operating.

96	steam plants with a total capacity of	1,238,106 kw.
32	Hydro-Electric Plants with a total capacity of	109,837 kw.
15	Gas Plants with a total capacity of	8,511 kw.
13	Combination Hydro and Steam plants with a total capacity of	85,905 kw.
5	" Hydro and Gas Plants with a total capacity of	863 kw.
2	" Steam and Gas Plants with a total capacity of	5,620 kw.

163—Total Number of Plants

Total Capacity—1,448,878 kw.

ELECTRIC POWER UTILITIES IN PENNSYLVANIA

Power Generated in Each County

No.	Name	Steam Generation K. W. H.	Steam Generation Coal Used	Hydro-Elec. K. W. H.	Gas or Oil K. W. H.	Total K. W. H. Generated
1.	Adams					
2.	Allegheny	1,063,473,096	991,874		2,876,769	1,066,349,865
3.	Armstrong				905,900	905,900
5.	Bedford	169,789	570	50,000	3,444,190	3,663,979
6.	Berks	110,816,562	141,566	1,720,741		112,537,303
7.	Blair	75,397,340	83,440			75,397,340
8.	Bradford	4,140,830	11,399			4,140,830
9.	Bucks		3,196			
11.	Cambria	13,873,093	33,456			13,873,093
12.	Cameron				600,000	600,000
13.	Carbon	236,947,675	400,934			236,947,675
14.	Centre	27,382,935	48,197			27,382,935
15.	Chester	65,307,297	69,453	3,307,075		68,614,372
16.	Clarion			267,000	200,000	467,000
17.	Clearfield	3,767,120	7,534			3,767,120
18.	Clinton	5,689,183	18,459			5,689,183
19.	Columbia			926,630	9,247	935,877
20.	Crawford				3,630,000	3,630,000
21.	Cumberland ...	18,570,021	43,987	333,880		18,903,901
22.	Dauphin	54,195,146	136,910	64,520		54,259,666
23.	Delaware	3,130,560	5,768			3,130,560
24.	Elk	36,248,000	54,759			36,248,000
25.	Erie	89,024,881	134,620			89,024,881
26.	Fayette	189,322,473	134,772	26,080		189,348,553
28.	Franklin	3,056,950	5,217	519,672		3,576,622
30.	Greene			32,517		32,517
31.	Huntingdon	33,722,670	42,296	7,438,192		41,160,862
33.	Jefferson	5,080,000	12,535		353,656	5,433,656
34.	Juniata				2,654	2,654
35.	Lackawanna ...	136,676,674	358,675			136,676,674
36.	Lancaster	1,141,393	3,324	1,950,050		3,091,443
37.	Lawrence			249,280		249,280
38.	Lebanon	1,459,059	3,995			1,459,059
40.	Luzerne	226,411,905	334,157	440,012		226,851,917
41.	Lycoming	26,171,031	43,389			26,171,031
42.	McKean				7,198,230	7,198,230
43.	Mercer	6,210,600	11,506		1,625,000	7,835,600
44.	Mifflin			873,930		873,930
45.	Monroe			1,397,875		1,397,875
46.	Montgomery ...	52,628,650	62,415			52,628,650
47.	Montour	146,000	1,620			146,000
48.	Northampton ..	90,795,340	113,452	8,650,875		99,446,215
49.	Northumberland.	1,628,865	5,437			1,628,865
50.	Perry	170,378	1,400			170,378
51.	Philadelphia ...	956,910,225	866,592	10,000,000		966,910,225
53.	Potter				681,090	681,090
54.	Schuylkill	49,028,070	90,813			49,028,070
55.	Snyder			723,605		723,605
56.	Somerset	20,673,450	30,045			20,673,450
57.	Sullivan	294,130	1,353	647,263		941,393
58.	Susquehanna ...	907,520	2,757	2,133,780		3,041,300
59.	Tioga	2,042,000	5,850			2,042,000
60.	Union			13,079		13,079
61.	Venango				110,860	110,860
62.	Warren	8,336,724	12,678			8,336,724
63.	Washington	1,522,900	1,523			1,522,900
64.	Wayne	2,833,000	5,664	250,000		3,083,000
65.	Westmoreland .	85,858,700	94,155			85,858,700
66.	Wyoming					
67.	York	24,606,050	59,751	441,723,303		466,329,353

TOTALS:

Total generation by Steam Prime Movers .... 3,725,396,601 K. W. H.
Total generation by Hydro Elec. Prime Movers .... 483,232,506 K. W. H.
Total generation by Gas or Oil Prime Movers .... 26,394,350 K. W. H.

Total Generation by Prime Movers .... 4,244,522,734 K. W. H.

Total Coal Consumed .... 4,578,902 short tons

PRIME POWER GENERATION BY COUNTIES—STEAM PLANTS
ELECTRIC POWER UTILITIES IN PENNSYLVANIA

County		Class "A" Steam Plants			Class "B" Steam Plants			Class "C" Steam Plants		
No.	Names	Kw. Cap.	Kwh. Gen.	Coal Used	Kw. Cap.	Kwh. Gen.	Coal Used	Kw. Cap.	Kwh. Gen.	Coal Used
1.	Adams	....	....	....	......	....	....	......	....	......
2.	Allegheny ...	282,000	1,035,575,857	1,010,183	25,400	17,404,090	17,404	6,350	10,493,149	26,612
5.	Bedford	....	....	....	40	35,000	150	700	134,789	420
6.	Berks	39,000	110,816,562	141,566	......	....	....	......	....	......
7.	Blair	....	....	....	17,000	67,175,260	65,011	2,750	8,222,080	18,429
8.	Bradford	....	....	....	......	....	....	2,685	4,800,830	13,548
9.	Bucks	....	....	....	......	....	....	460	....	3,196
11.	Cambria	....	....	....	11,600	5,467,539	8,201	4,980	8,405,554	25,255
13.	Carbon	56,000	236,162,005	398,634	......	....	....	400	785,670	2,300
14.	Centre	....	....	....	14,565	27,382,935	48,197	......	....	......
15.	Chester	....	....	....	20,000	50,539,199	51,966	3,860	5,376,148	17,487
17.	Clearfield	....	....	....	......	....	....	2,950	3,767,120	7,534
18.	Clinton	....	....	....	5,000	4,472,200	8,725	800	1,216,983	9,734
20.	Crawford	....	....	....	......	....	....	150	....	......
21.	Cumberland..	....	....	....	3,175	3,760,261	6,957	4,000	14,809,760	37,030
22.	Dauphin	....	....	....	28,615	46,760,286	119,084	4,400	7,434,860	17.826
23.	Delaware	....	....	....	......	....	....	1,755	3,130,560	5,768
24	Elk	....	... .	....	15,000	36,248,000	54,759	......	....	......
25.	Erie	....	... .	....	47,000	89,024,881	134,620	......	.... ..	......
26.	Fayette	56,500	187,594,473	137,599	......	....	....	450	1.728,000	3,456
28.	Franklin	....	....	....	500	626,600	1,567	2,500	2,430,350	3,650
31.	Huntingdon..	....	....	....	7,500	33,722,670	42,296	......	....	......
33.	Jefferson	......	....	....	......	....	....	1,300	5,080,000	12,535
35.	Lackawanna..	......	....	....	47,200	114,891,245	290,964	10,910	21,785,429	67,711
36.	Lancaster ...	....	....	....	......	....	....	875	1,141,393	3,324
38.	Lebanon	....	....	....	......	....	....	2,000	1,459,059	3,9[illegible]5
40.	Luzerne	41,500	143,405,900	250,955	38,300	83,006,105	101,122	......	....	......
41.	Lycoming ...	....	....	....	......	....	....	14,827	26,171,031	43,389
43.	Mercer	....	....	....	......	....	....	2,500	6,210,600	11,506
46.	Montgomery..	....	....	....	20,000	50,941,040	57,015	2,025	1,687,610	6,682
47.	Montour	....	....	....	......	....	....	150	146,000	1,620
48.	Northampton	....	....	....	35,000	88,428,400	109,286	750	2,366,940	4,166
49.	Northumberl'd	....	....	....	......	....	....	3,595	1,628,865	5,437

50.	Perry	....	....	....	......	....	....	100	170,378	1,400
51.	Philadelphia..	336,230	956,910,225	866,592	......	....	....	......	....	......
54.	Schuylkill	....	....	....	10,200	47,913,170	86,369	725	1,114,900	4,444
56.	Somerset	....	....	....	8,500	19,170,100	24,255	1,230	1,503,350	5,290
57.	Sullivan	....	....	....	......	....	....	450	294,130	1,353
58.	Susquehanna..	....	....	....	500	907,520	2,756	......	....	......
59.	Tioga	....	....	....	......	....	....	2,185	2,042,000	5,850
62.	Warren	....	....	....	......	....	....	6,000	8,336,724	12,678
63.	Washington ..	....	....	....	......	....	....	900	1,522,900	1,523
64.	Wayne	....	....	....	175	500,000	1,050	975	2,282,000	4,614
65.	Westm'l'd ...	50,000	85,858,700	94,155	......	....	....	......	....	......
67.	York	....	....	....	......	....	....	12,525	24,606,050	59,751

	Kw. Cap.	Kwh. Generated	Coal Used (Lbs.)
TOTALS:			
Class "A" Steam Plants	855,230	2,756,323,722	2,899,784 short T.
Class "B" Steam Plants	355,270	787,396,601	1,231,754 short T.
Class "C" Steam Plants	103,092	181,971,675	447,364 short T.
Total:	1,313,592	3,725,091,908	4,578,902 short T.

PRIME POWER GENERATION BY COUNTIES—HYDRO-ELECTRIC, GAS & OIL ELECTRIC POWER UTILITIES IN PENNSYLVANIA

County		Hydro-Elec. Plants				Gas Engines			Oil Engines		
		(Class A)		(Class B)							
No.	Name	Kw. Cap.	Kwh. Gen.	Kw. Cap.	Kwh. Gen.	Kw. Cap.	Kwh. Gen.	M. cu. ft. Gas Used	Kw. Cap.	Kwh. Gen.	Gals. Oil Used
1.	Adams	......	....	27	....	.....	....	......	.....	....	......
2.	Allegheny	......	....	.....	....	1,710	2,876,769	......	.....	....	......
3.	Armstrong	......	....	.....	....	710	905,900	......	.....	....	......
5.	Bedford	......	....	150	50,000	400	3,444,190	55,761	.....	....	......
6.	Berks	......	....	685	1,745,741	.....	....	......	.....	....	......
12.	Cameron	......	....	.....	....	375	600,000	......	.....	....	......
14.	Centre	......	....	150	(see steam)	.....	....	......	.....	....	......
15.	Chester	......	....	1,413	3,307,075	.....	....	......	.....	....	......
16.	Clarion	......	....	150	267,760	520	377,875	......	.....	....	......
19.	Columbia	......	....	300	926,630	.....	....	......	50	9,247	......
20.	Crawford	......	....	.....	....	935	3,630,000	......	.....	....	......
21.	Cumberland	......	....	747	333,880	.....	....	......	.....	....	......
22.	Dauphin	......	....	150	64,520	.....	....	......	900	4,487,940	......
26.	Fayette	......	....	60	26,080	.....	....	......	.....	....	......
28.	Franklin	......	....	915	519,672	.....	....	......	.....	....	......
30.	Greene	......	....	.....	....	500	32,517	......	.....	....	......
31.	Huntingdon	......	....	3,137	7,438,192	.....	....	......	.....	....	......
33.	Jefferson	......	....	.....	....	561	353,656	......	......	.....	....
34.	Juniata	......	....	.....	....	.....	....	......	3	2,654	......
36.	Lancaster	......	....	300	1,950,050	.....	....	......	.....	....	......
37.	Lawrence	......	....	1,250	249,280	.....	....	......	.....	....	......
40.	Luzerne	.....	....	352	440,012	.....	....	......	.....	....	......
42.	McKean	......	....	.....	....	.....	....	......	2,365	7,198,230	......
43.	Mercer	......	....	.....	....	525	1,625,000	......	.....	....	......
44.	Mifflin	......	....	300	873,930	.....	....	......	.....	....	......
45.	Monroe	......	....	958	1,397,875	.....	....	......	.....	....	......
48.	Northampton	......	....	1,750	8,150,779	.....	....	......	.....	....	......
50.	Perry	......	....	90	....	.....	....	......	.....	....	......
51.	Philadelphia	......	....	1,600	10,000,000	.....	....	......	.....	....	......
53.	Potter	......	....	.....	....	437	681,090	......	.....	....	......
55.	Snyder	......	....	250	732,605	.....	....	......	.....	....	......

57.	Sullivan	......	....	240	647,263	.....	....	......	.....	....	......
58.	Susquehanna..	......	....	1,400	2,133,780	.....	....	......	.....	....	......
60.	Union	......	....	125	13,079	.....	....	......	.....	....	29,634
61.	Venango	......	....	.....	....	900	110,860	......	.....	....	......
64.	Wayne	......	....	480	250,000	.....	....	......	.....	....	......
66	Wyoming	......	....	300	....	.....	....	......	.....	....	......
67.	York	98,500	441,318,595	215	404,708	.....	....	......	.....	....	......

TOTALS:

Class "A" Hydro-Elec. Plants	98,500	441,318,595
Class "B" Hydro-Elec. Plants	17,494	41,913,911
Total Hydro-Electric Plants	115,994	483,232,506
Class "C" Gas Engines	7,573	14,637,757
Class "C" Oil Engines	3,318	11,698,070
Total Gas and Oil Engine Plants	10,891	26,245,728

STATION CAPACITIES AND KWH. GENERATED—CLASS "A" PLANTS
Plants Controlled by Holding Companies
ELECTRIC POWER UTILITIES IN PENNSYLVANIA

Name of Holding Company	Steam Generating Plants			Hydro-Elec. Plants		Total	Total Kwh.
Name of Local Company	Kw. Cap.	Kwh. Gen.	Lb. Coal Used	Kw. Cap.	Kwh. Gen.	Kw. Cap.	Generated
D American Water Wks. & Elec. Co.							
West Penn Power Company	....	....	....	......	....	98,500	395,346,730
Connellsville	56,500	187,594,473	275,188,946	......	....	....	....
Springdale	42,000	207,752,257	415,504,514	......	....	....	....
Windsor, W. Va.	30,000	229,990,015	Generated in West Virginia.			....	....
G Electric Bond & Share Company							
Penna. Power & Light Co.	....	....	....	......	....	91,500	379,567,905
Harwood Mines	41,500	143,405,900	501,910,650	......	....	....	....
Hauto	50,000	236,162,005	797,267,580	......	....	....	....
H General Gas & Electric Company		....	....	......	....	54,000	188,031,748
Metropolitan Edison Co.	39,000	110,816,562	283,132,000	......	....	....	....
York Haven Water & Pw. Co.	....	....	....	15,000	77,215,186	....	....
L Pennsylvania Electric Company							
Penn Public Service Corp.	50,000	85,858,700	188,309,504	......	....	50,000	85,858,700
N Pennsylvania Water & Power Co.							
Penna. Water & Power Co.	....	....	....	83,500	364,103,409	83,500	364,103,409
O Philadelphia Electric Company							
Philadelphia Electric Co.	336,230	956,910,225	1,733,184,274	......	....	336,230	956,910,225
S United Railway Investment Co.							
Duquesne Light Company	....	....	....	......	....	240,000	845,227,690
Brunot Is	120,000	407,111,400	....	......	....	....	....
			1,604,862,467				
Colfax	120,000	420,712,200	....	......	....	....	....

TOTALS:	Kw. Capacity	Kwh. Generated	Coal Used (Lbs.)
Steam Plants	855,230	2,756,323,722	5,799,359,935
Hydro-Elec. Plants	98,500	441,318,595	....

STATION CAPACITIES AND KWH. GENERATED—CLASS "B" PLANTS
Plants Controlled by Holding Companies
ELECTRIC POWER UTILITIES IN PENNSYLVANIA

Name of Holding Company / Name of Local Company	Steam Generating Plants			Hydro Elec. Plants		Total Kw. Cap.	Total Kwh. Generated
	Kw. Cap.	Kwh. Gen.	Lb. Coal Used	Kw. Cap.	Kwh. Gen.		
C American Gas Company	......	......	......	......	......	42,850	90,454,320
Luzerne Co. Gas & Elec. Co.	22,500	53,564,920	181,105,500	......	......	......	......
Philadelphia Sub. Gas & El. Co.	20,000	50,039,299	......	300	375,000	......	......
D American Water Wks. & Elec. Co.	......	......	......	......	......	18,910	43,971,000
Fayetteville El. Lt. & Pw. Co.	......	......	......	20	7,872	......	......
Hyndmann Elec. Lt., Ht. & Pw. Co.	40	35,000	300,000	75	25,000	......	......
Keystone Power Co. (Milesburg)	3,565	7,688,000	37,250,000	150	......	......	......
Keystone Power Corp. (Ridgway)	15,000	36,248,000	109,518,000	......	......	......	......
West Penn Power Co.	......	......	......	60	26,080	......	......
West Penn Power Co. (Clarion)	......	......	......	150	267,760	......	......
F Eastern Pa. Pw. & Ry. Co.	......	......	......	......	......	47,225	143,019,668
Eastern Pa. Lt., Ht. & Pw. Co.	10,200	47,913,170	172,738,944	......	......	......	......
Pa. Edison Co. (Columbia, N. J.)	......	......	......	270			
Easton	35,000	88,428,400	218,536,448	1,000	5,338,779	......	......
Stroudsburg	......	......	......	785	1,338,729	......	......
G Electric Bond & Share Co.	......	......	......	......	......	68,875	151,164,865
Lock Haven Elec. Co.	5,000	4,472,200	17,450,700	......	......	......	......
Paupack Elec. Co.	175	500,000	2,100,000	355	250,000	......	......
Pa. Pw. & Lt. Co. (Bloomsburg)	......	......	......	200	886,630	......	......
Selinsgrove	......	......	......	250	723,605	......	......
Wilkes-Barre	14,000	26,067,105	104,268,420	......	......	......	......
Scranton El. Co. (Scranton)	47,200	114,891,245	565,057,600	......	......	......	......
Pittston	1,800	3,374,080	16,870,400	......	......	......	......
H General Gas & Elec. Co.	......	......	......	......	......	500	1,504,240
Metropolitan Edison Co.	......	......	......	500	1,504,240	......	......
L Pennsylvania Electric Co.	......	......	......	......	......	57,500	88,624,752
Erie Lighting Co.	......	......	......	......	......	......	......
Penn Pub. Ser. Corp. (Erie)	24,500	51,230,880	153,692,640	......	......	......	......
Philipsburg	11,000	19,714,935	59,144,805	......	......	......	......
Rockwood	8,500	19,170,100	48,510,300	......	......	......	......

STATION CAPACITIES AND KWH. GENERATED—CLASS "B" PLANTS—Continued
Plants Controlled by Holding Companies
ELECTRIC POWER UTILITIES IN PENNSYLVANIA

Name of Holding Company	Steam Generating Plants			Hydro. Elec. Plants		Total	Total Kwh.
Name of Local Company	Kw. Cap.	Kwh. Gen.	Lb. Coal Used	Kw. Cap.	Kwh. Gen.	Kw. Cap.	Generated
Susquehanna Lt. & Pw. Co. (Oakland)	500	907,520	5,512,000	1,400	2,133,780	....	....
Penn Pub. Ser. Corp. (Johnstown)	11,600	5,467,539	16,402,617	......	....	....	....
M Penn Central Lt. & Pw. Co.	....	....	....	......	....	25,800	100,812,072
Penn Central Lt. & Pw. Co.							
Warrior Ridge	6,500	30,019,720	67,273,624	2,000	3,617,092	....	....
Williamsburg	17,000	67,175,260	130,021,880	......	....	....	....
Yeagertown Water Pw. Co.	....	....	....	300	873,930	....	....
P R public Ry. & Lt. Co.							
Pennsylvania Pw. Co.	....	....	....	1,250	249,280	1,250	249,280
Q United Gas & Electric Corp.	....	....	....	......	....	23,495	30,758,750
Harrisburg Lt. & Pw. Co.	23,195	28,808,700	189,122,000	......	....	....	....
Lancaster El. Lt., Ht. & Pw. Co. ...	....	....	....	300	1,950,050	....	....
R United Gas Improvement Co.	....	....	....	......	....	20,000	50,941,040
Counties Gas & Elec. Co.	20,000	50,941,040	122,746,729	......	....	....	....
S United Ry Inv. Co.	....	....	....	......	....	25,400	17,404,090
Duquesne Light Co.	25,400	17,404,090	30,808,180	......	....	....	....

TOTALS:	Kw. Capacity	Kwh. Generated	Coal Used (Lbs.)
Steam Plants	322,675	724,561,203	2,252,439,787
Hydro-Elec. Plants	9,095	19,567,827	....

ELECTRIC POWER UTILITIES IN PENNSYLVANIA
Station Capacity and Kwh. Generated—Class "C" Plants
Plants Controlled by Holding Companies

Name of Holding Co. / Name of Local Co.	Steam Generating Plants			Internal Combustion Eng. Plants					
	Kw. Cap.	Kwh. Gen.	Coal Used (lbs.)	Kw. Cap.	Kwh. Gen.	Oil Used (gals.)	Gas Used (cu. ft.)	Kw. Cap.	Gen.
B American El. Pw. Co.	......	....	....	.....	....	.....	.....	1,000	4,519,130
Home El. Lt. & Stm. Htg. Co. ...	1,000	4,519,130	19,674,090	.....	....	.....	.....	......	....
C American Gas Co.	......	....	....	.....	....	.....	.....	860	2,263,952
Phila. Sub. G. & E. Co.	860	2,263,952	9,065,808	.....	....	.....	.....	......	....
D Am. Water W & E. Co.	......	....	....	.....	....	.....	.....	3,162	5,820,857
Home Elec Co.	......	....	....	437	681,090	.....	.....	......	....
Keystone Pw. Co.	......	....	....	1,225	3,584,000	.....	.....	......	....
West Penn Pw. Co.									
Kittanning	......	....	....	100	350	.....	.....	......	....
Washington	900	1,522,900	4,568,700	.....	....	.....	.....	......	....
Waynesburg	......	....	....	500	32,517	.....	.....	......	....
Clarion	......	....	....	520	377,875	.....	.....	......	....
F E. Pa. Pw. & Ry. Co.	......	....	....	.....	....	.....	.....	2,650	2,265,220
E. Penn Elec. Co.	2,650	2,265,220	13,591,320	.....	....	.....	.....	......	....
G Elec. B. & S. Co.	......	....	....	.....	....	.....	.....	18,647	48,908,411
Citizens Elec. Co.	1,342	1,500,000	14,000,000	.....	....	.....	.....	......	....
Honesdale Con. L., H. & P. Co. ...	800	1,782,000	7,128,000	.....	....	.....	.....	......	....
Jersey Shore El. Co.	1,205	1,373,671	7,556,000	.....	....	.....	.....	......	....
Lack. & Wyo. V. Pw. Co.	9,265	20,157,660	117,073,600	.....	....	.....	.....	......	....
Lycoming Ed. Co.	11,900	23,031,710	64,769,900	.....	....	.....	.....	......	....
Pa. P. & L. Co. (Shamokin)	3,400	1,063,370	5,316,850	.....	....	.....	.....	......	....
H Gen. Gas. & El. Co.	......	....	....	.....	....	.....	.....	12,175	21,181,419
Ed. Lt. & Pw. Co.	8,525	16,386,530	96,304,320	.....	....	.....	.....	......	....
Metropolitan Ed. Co.	2,000	1,459,059	7,870,000	.....	....	.....	.....	......	....
Sayre Elec. Co.	1,650	3,335,830	16,537,580	.....	....	.....	.....	......	....
I Juniata Pub. Ser. Corp.	......	....	....	.....	....	.....	.....	1,750	5,169,640
Juniata Pub. Ser. Co.	1,750	5,169,640	22,060,000	.....	....	.....	.....	......	....
J Municipal Service Co.	......	....	....	.....	....	.....	.....	3,900	3,223,055
Citizens Lt. & Pw. Co.	......	....	....	900	110,860	.....	.....	......	....

ELECTRIC POWER UTILITIES IN PENNSYLVANIA—Continued
Station Capacity and Kwh. Generated—Class "C" Plants
Plants Controlled by Holding Companies

Name of Holding Co. / Name of Local Company	Steam Generating Plants			Internal Combustion Eng. Plants					
	Kw. Cap.	Kwh. Gen.	Coal Used (lbs.)	Kw. Cap	Kwh. Gen.	Oil Used (gals.)	Gas Used (cu. ft.)	Kw. Cap	Gen.
Chester Valley El. Co.	3,000	3,112,195	16,055,840	.....	....	.....	...	......	....
L Penna. Electric Co.	......	....	....	.....	....	.....	..	13,950	24,962,884
Hanover Pw. Co.	4,000	8,219,520	23,198,000	.....	....	.....	.	......	....
Penn Public Ser. Corp.									
Clearfield	600	1,694,820	6,779,280	.....	....	.....	..	......	....
DuBois	2,350	2,072,300	8,289,200	.....	....	.....	...	......	....
Punxsutawney	1,000	4,639,520	18,550,080	.....	....	.....	...	......	....
Warren	6,000	8,336,724	33,346,886	.....	....	.....	....	......	....
R United Gas Imp. Co.	......	....	....	.....	....	.....	.....	1,630	2,905,560
Counties Gas & El. Co.	1,630	2,905,560	8,716,580	.....	....	.....	.....	......	....

TOTALS:	Kw. Capacity	Kwh. Generated	Coal or Oil Used (Lbs.)
Steam Plants	....	117,184,311	520,450,034 lbs.
Gas or Oil Eng. Plants	....	4,786,692	....

POPULATION SERVED AND COUNTIES IN WHICH HOLDING COMPANIES OPERATE

Name of Holding Company	Population to whom Local service is furnished.	Counties in which local service is furnished (Counties by Numerical Index.)
A. Allentown & Reading Traction Co.	2,189	6
B. American Electric Power Co.	35,569	7-15-31
C. American Gas Company	178,241	9-15-40-46
D. American Water Wks. & Elec. Co.	347,511	2-3-5-10-14-16-24-26-28-30-32-42-53-63
E. Consolidated Utilities Co.	3,723	20-25
F. Eastern Pa. Pw. & Ry. Co.	90,013	19-22-54
G. Electric Bond & Share Co.	834,153	9-13-18-19-35-39-40-41-45-46-47-48-49-54-55-58-60-64
H. General Gas & Electric Co.	269,384	1-6-8-22-36-38-67
I. Juniata Public Service Corp.	6,262	34-50
J. Municipal Service Company	57,177	15-61
K. Pa. Ohio Pw. & Lt. Co.	45,098	43-37
L. Pennsylvania Elec. Co.	280,553	11-14-17-20-25-32-33-56-61-62-65-67
M. Penn Central Lt. & Pw. Co.	110,956	7-11-31-32-44
N. Penna. Water & Power Co.	No Local Service	67
O. Philadelphia Electric Co.	1,945,361	23-46-51
P. Republic Ry. & Lt. Co.	No Local Service	10
Q. United Gas & Electric Corp.	198,410	6-15-22-36
R. United Gas Improvement Co.	50,310	15-23-46
S. United Railway Inv. Co.	971,250	2-10

PRIME POWER SOURCES
Controlled by
HOLDING COMPANIES

The nineteen holding companies controlling electric light and power properties in Pennsylvania operate in 58 counties in the State and furnish service available to a total population of 5,426,169.

The total Prime Power Sources controlled by these companies as of record January 1, 1923.

CLASS "A" GENERATING PLANTS.
(Efficient plants of over 25,000 kw. capacity.)

Steam Generating Plants ....855,230 kw. Installed Capacity
2,756,323,722 kwh. Generated during 1922.

Hydro Electric Gen. Plants .... 98,500 kw. Installed Capacity
441,318,594 kwh. Generated during 1922.

CLASS "B" GENERATING PLANTS.
(Inefficient plants and plants of less than 25,000 kw. cap. and all hydro-elec. plants.)

Steam Generating Plants ....322,675 kw. Installed Capacity
724,561,203 kwh. Generated during 1922.

Hydro Electric Gen. Plants .... 9,095 kw. Installed Capacity
19,567,827 kwh. Generated during 1922.

CLASS "C" GENERATING PLANTS.
(All plants not included in "A" and "B")

Steam Generating Plants .... 65,827 kw. Installed Capacity
117,184,311 kwh. Generated during 1922

Gas or Oil Engine Gen. Plants .... 3,682 kw. Installed Capacity
4,786,692 kwh. Generated during 1922

Total Prime Power Capacity Installed in Plants of Controlled Companies .... 1,354,009 kw.

Total kwh. Generated by Controlled Companies .... 4,063,651,350 kwh.

STATION CAPACITIES AND KWH. GENERATED—CLASS "B" PLANTS

Local Companies

Name of Local Company	Steam Generating Plants			Hydro-Elec. Plants		Total	Total
	Kw. Cap.	Kwh. Gen.	Lb. Coal Used	Kw. Cap.	Kwh. Gen.	Kw. Cap.	Kwh. Gen.
Arendtsville Elec. Lt. Plant	Combined	....	....	....	....	27	....
B[illegible] Co.	Combined	Hydro & Oil	....	100	40,000	150	49,247
Bernville Lt., Ht. & Pw. Co.	......	....	....	85	100,000	85	100,000
Big Spring Elec. Co.	75	60,361	964,300	135	73,500	210	133,861
Birds[illegible]	......	....	....	75	116,501	75	166,501
Blue Mountain Elec. Co.	......	....	....	25	25,000	25	25,000
Boiling Spg El. Lt. & Water Co.	......	....	....	50	30,000	50	30,000
Carlisle Gas & Water Co.	3,100	3,699,900	12,949,650	450	182,600	3,450	3,982,500
Clymer Power Co.	......	....	....	750	2,812,100	750	2,812,100
Cumberland Valley Lt. & Pw. Co.	......	....	....	75	45,000	75	45,000
Deal Elec. Lt. & Pw. Plant	35	....	....	75	25,000	110	25,000
Delta Water Power Co.	......	....	....	165	350,000	165	350,000
Eagles Mere Lt. Co.	......	....	....	240	647,263	240	647,263
Erie Co. Elec. Co.	22,500	37,794,000	115,548,000	....	....	22,500	37,794,000
Fawn Lt. & Pw. Co.	......	....	....	50	54,708	50	54,708
French Creek El. Co.	.....	....	....	18	27,375	18	27,375
Heller Milling Co.	......	....	....	27½	122,640	27½	122,640
Hershey Elec. Co.	5,420	16,951,586	49,045,232	....	....	5,420	49,045,232
Wm. I. Hoffman	......	....	....	37½	2,780	37½	2,780
Hummelstown Water & Pw. Co.	......	....	....	150	64,520	150	64,520
Mercerbg, Lehmaster & Mar es El. Co.	Combined	Hydro & Oil	....	150	146,800	150	146,800
Mount Pocono Lt. & Pw. Co.	Combined	Hydro & Oil	....	68	40,160	68	40,160
Naomi Pines Elec Co.	......	....	....	60	7,026	60	7,026
Orbisonia Lt. Co.	Combined	Hydro & Steam	80,000	37	12,000	37	12,000
Penns Creek Hydro Elec. Co.	Combined	Hydro & Oil	....	125	13,079	125	13,079
Philadelphia Hydro-Elec. Co.	......	....	....	1,600	10,000,000	1,600	10,000,000
Phoenix Water Pw. Co.	......	....	....	1,095	2,904,700	1,095	2,904,700
Raystown Water Pw. Co.	1,000	3,702,950	17,184,832	2,100	3,809,100	3,100	7,502,050
Saylorsburg Lt. & Pw. Co.	......	....	....	45	11,910	45	11,910
Shermans Valley Lt., Ht. & Pw. Co.	......	....	....	90	....	90	....
Shippensburg Gas & El. Co.	500	626,600	3,133,000	745	365,000	1,245	991,600
Tunkhannock Elec. Co.	Combined	Hydro & Steam	....	300	....	300	....
Varden & Lake Ariel L., H. & P. Co.	......	....	....	125	....	125	....
White Haven El. Ill.	......	....	....	325	317,372	325	317,372

TOTALS:

	Kw. Capacity	Kwh. Generated	Coal Used (Lbs.)
Steam Plants	32,595	62,835,397	208,635,014
Hydro Elec. Plants	8,399	12,346,134	....

ELECTRIC POWER UTILITIES IN PENNSYLVANIA
STATION CAPACITY AND KWH. GENERATED—CLASS "C" PLANTS
Local Companies

Name of Local Co.	Steam Generating Plants			Internal Combustion Eng. Plants				Total	Total
	Kw. Cap.	Kwh. Gen.	Coal Used (lbs.)	Kw. Cap	Kwh. Gen.	Oil Used (gals.)	Gas Used (cu. ft.)	Kw.Cap.	Kwh. Gen.
Aspinwall Mun. Plt.	1,000	1,460,000	9,000,000	.....	....	....	....	1,000	1,460,000
Bangor Elec. Co.	750	2,366,940	8,332,000	.....	....	....	....	750	2,366,940
Barnesboro-Spangler El. Lt. Co.	2,600	4,170,170	20,952,336	.....	....	....	....	2,600	4,170,170
Benton Hydro Elec. Co.	.....	....	....	50	9,247	....	....	50	9,247
Bedford El. L., H. & P. Co.	.....	....	....	400	3,444,190	....	55,761,000	400	3,444,190
Boyertown El. Co.	Reserve	Plant	....	.....	....	....	....	.....	....
Bradford Elec. Co.	.....	....	....	1,140	3,614,230	....	....	1,140	3,614,230
Brockway L., H. & P. Co.	300	440,480	6,520,000	.....	....	....	....	300	440,480
Chambersburg Mun. Plt.	2,500	2,430,350	7,300,000	.....	....	....	....	2,500	2,430,350
Confluence Mun. Plt.	60	....	....	.....	....	....	....	60	....
Coraopolis Mun. Plt.	.....	....	....	820	1,696,000	....	....	820	1,696,000
Dalmatia Lt. Co.	60	25,495	127,475	.....	....	....	....	60	25,495
Danville Mun. Plt.	150	146,000	3,240,000	.....	....	....	....	150	146,000
Dunbar Elec. Co.	450	1,728,000	6,912,000	.....	....	....	....	450	1,728,000
Duncannon Mun. Plt.	100	170,378	2,800,000	.....	....	....	....	100	170,378
Ebensburg L., H. & P. Co.	630	790,094	5,475,866	.....	....	....	....	630	790,094
Emporium Mun. Plt.	.....	....	....	375	600,000	....	....	375	600,000
Ephrata Mun. Plt.	875	1,141,393	6,648,000	.....	....	....	....	875	1,141,393
Etna Mun. Plt.	Reserve	Plant	....	.....	....	....	....	.....	....
Everett L., H. & Pw. Co.	700	134,789	840,000	.....	....	....	....	700	134,789
Ford City Mun. Plt.	.....	....	....	610	905,550	....	....	610	905,550
Grove City Mun. Plt.	.....	....	....	525	1,625,000	....	....	525	1,625,000
Hershey Elec. Co.	.....	....	....	900	4,487,940	348,338	....	900	4,487,940
Lansdale Mun. Plt.	1,500	1,687,610	10,800,000	.....	....	....	....	1,500	1,687,610
Logan L., H. & P. Co.	Reserve	Plant	....	.....	....	....	....	.....	....
McAlisterville Mun. Plt.	.....	....	....	3	2,654	Gasoline	Plant	3	2,654
Media Mun. Plt.	125	225,000	2,820,000	.....	....	....	....	125	225,000
Mercer Co. L., H. & P. Co.	2,500	6,210,600	23,011,560	.....	....	....	....	2,500	6,210,600
Meyersdale E L., H. & P. Co.	1,170	1,503,350	10,580,000	.....	....	....	....	1,170	1,503,350
Mont. & Muncy E. L., H. & P. Co.	Reserve	Plant	....	.....	....	....	....	.....	....
Montoursville El. Lt. Co.	380	265,650	450,800	.....	....	....	....	380	265,650

Natrona Lt. & Pw. Co.	2,500	5,446,826	10,893,724	....	....	....	....	2,500	5,446,862
North Penn Power Co.									
Blossburg	660	400,000							
Canton	200	350,000							
Mansfield	250	425,000	10,575,000	.....	....	....	....	1,235	1,425,000
Troy	125	250,000							
Olyphant Mun. Plant	450	1,084,800	10,848,000	.....	....	....	....	450	1,084,800
Orangeville El. L. & P. Co.	Reserve	Plant	....	.....	....	....	....	.....	....
Oxford Elec. Co.	Reserve	Plant	....	.....	....	....	....	.....	....
Pecksville Mun. Plant	475	542,969	7,500,000	.....	....	....	....	475	542,969
Pennsburg Mun. Plt.	525	....	2,586,000	.....	....	....	....	525	....
Perkasie Mun. Plt.	460	....	6,492,000	.....	....	....	....	460	....
Pitcairn Mun. Plat.	.....	....	....	600	1,000,000	....	....	600	1,000,000
Quakertown Mun. Plt.	Reserve	Plant	....	.....	....	....	....	.....	....
Raystown Water Pw. Co.	1,750	3,702,950	17,184,832	.....	....	....	....	1,750	3,702,950
Renovo Ed. L. H. & P. Co.	800	1,216,983	19,468,000	.....	....	....	....	800	1,216,983
Schuylkill Haven Mun. Plt.	725	1,114,900	8,889,200	.....	....	....	....	725	1,114,900
Sharpsburg Mun. Plt.	1,350	1,729,430	15,000,000	.....	....	....	....	1,350	1,729,430
Solar Elec. Co.	.....	....	....	561	353,565	....	....	561	353,565
St. Claire Mun. Plt.	Reserve	Plant	....	.....	....	....	....	.....	....
Sullivan Co. El. Co.	450	294,130	2,706,549	.....	....	....	....	450	294,130
Tarentum Mun. Plt.	1,500	1,856,857	14,330,000	.....	....	....	....	1,500	1,856,857
Titusville Lt. & Pw. Co.	.....	....	....	935	3,630,000	....	....	935	3,630,000
Titusville Mun. Plt.	150	....	....	.....	....	....	....	150	....
Towanda Gas & El. Co.	600	650,000	....	.....	....	....	....	600	650,000
Troy El. L., H. & P. Co.	110	215,000	1,760,000	.....	....	....	....	110	215,000
United El. Lt. Co.	.....	....	....	290	180,769	....	....	290	180,769
United Elec. Co.	4,600	14,809,760	74,060,400	.....	....	....	....	4,600	14,809,760
Valley Elec. Ser. Co.	50	156,000	3,270,000	.....	....	....	....	50	156,000
Vinton Colliery Co.	1,750	3,445,290	24,082,000	.....	....	....	....	1,750	3,445,290
Watsontown Mun. Plt.	85	384,000	2,160,000	.....	....	....	....	85	348,000
Weatherly Mun. Plt.	400	758,670	4,600,000	.....	....	....	....	400	758,670
Wellsboro El. Co.	1,275	1,217,000	5,625,550	.....	....	....	....	1,275	1,217,000
Paupack Elec. Co.	175	500,000	2,100,000	.....	....	....	....	.....	....

TOTALS:	Kw. Capacity	Kwh. Generated	Coal Used (Lbs.)
Steam Plants	37,265	64,787,364	367,841,292
Oil or Gas	7,209	21,549,145	....

ELECTRIC COMPANIES SELLING OR DELIVERING POWER TO ELECTRIC UTILITIES
Controlled by Holding Companies

Name of Holding Company Name of Local Company	Name of Utility Receiving Power	Kwh. Delivered to El. Lt. & Pw. Co.	Kwh. Delivered to St. Ry. Co.	Counties (by No.) in which company delivering power furnishes service
A Allentown & Reading Trac. Co.				
Fleetwood-Kutztown E. L., H. & P. Co.	Allentown & Reading Trac. Co.	....	840,000	6
B American Elec. Power Co.				
Home El. Lt. & Stm. Htg. Co.	Penn Central Lt. & Pw. Co.	10,860	....	31-7
	Altoona & Logan V. El. Ry.	....	1,186,180	....
C American Gas Company				
E. Penna. Gas & El. Co.	Langhorne Electric Co.	556,500	....	9
(Now Phila. Sub. Co.)	Trenton, Bristol, & Phila. St. Ry. Co.	....	683,400	....
Luzerne County G. & E. Co.	Harveys Lake Lt. Co.	114,730	....	....
	Peoples St. Ry Co., Wanamic	....	1,088,000	40
Phila. Sub. G. & E. Co.	Chester Valley Elec. Co.	13,060,705	....	46
	Metropolitan Ed. Co.	491,280	....	....
	Phoenixville Valley	....	161,638	....
	Pottstown & Read. St. Ry. Co.	....	737,611	....
	Montgomery & Chester St. Ry.	....	239,627	....
D American W. Wks & El. Co.				
Keystone Power Corp.	Center Elec. Co.	94,340	....	14-18-24-42-53
Waynesboro Elec. Co.	Mont Alto	13,500	....	28
	Blue Ridge	66,400	....	....
	Greencastle	471,200	....	....
West Penn Power Co.	Dunbar Elec. Co.	490,100	....	30-63-65- 1-26- 3-10-16
	Brook Elec. Co.	10,109,637	....	....
	W. Virginia & Md. Pw. Co.	315,101	....	....
	Duquesne Lt. Co.	8,865,559	....	....
	Ohio Pw. Co.	78,122	....	....
	Pittsburgh Railways Co.	....	20,300	....
	Fairchance & Smithfield Tr. Co.	....	63,333	....
	Butler Pass. St. Ry. Co.	....	646,196	....
	Westmoreland Co. St. Ry. Co.	....	261,072	....
	West Side Railways Co.	....	1,201,280	....
	Irwin & Herminie Trac. Co.	....	332,717	....
	West Penn Rys. Co.	....	24,224,548	....
	Allegheny Valley St. Ry. Co.	....	2,457,948	....

E Consolidated Utilities Company				
United Electric Co.	Juniata Pub. Ser. Co.	149,250	....	21-50-67
	New Kingston Lt. & Pw. Co.	22,919	....	....
	Dillsburg Lt. & Pw. Co.	533,270	....	....
United Electric Co.	Valley Railways Co.	....	3,815,143	21-50-67
	Carlisle & Mt. Holly Ry. Co.	....	146,400	....
F E. Pa. Pw. & Rys. Co.				
E. Pa. Lt., Ht. & Pw. Co.	Pine Grove El. Lt., Ht. & Pw. Co.	596,800	....	19-54
	St. Claire M. P.	820,400	....	....
	Metropolitan Ed. Co.	49,065	....	....
	Eastern Pa. Ry. Co.	....	631,290	....
	Pottsville Union Trac. Co.	....	4,959,734	....
East Penn Elec. C.	Gratz Lt. Co.	24,060	....	22-54
	Lykens Valley Ry. Co.	....	252,310	....
G Electric Bond & Share Co.				
Excelsior E. L. & P. Co.	Souderton	547,953	....	9-46
	Hatfield M P.	230,320	....	....
Honesdale Con. Lt., Ht., & Pw. Co.	Beach Lake El. Co.	6,620	....	64
	Bethany Elec. Co.	11,077	....	....
	Cherry Ridge Elec. Co.	5,189	....	....
	Prompton Elec. Co.	10,378	....	....
Jersey Shore Elec. Co.	Jersey Shore El St. Ry. Co.	....	481,000	41
Lackawanna & Wyo. V. Pw. Co.	Scranton El. Co.	6,585,576	....	35-40
	L. & W. V. R. R. Co.	....	8,410,918	....
Lock Haven Elec. Co.	Susquehanna Trac. Co.	....	416,445	18
Lycoming Edison Co.	Williamsport Pass. Ry. Co.	....	2,185,674	41
	South Side Pass. Ry. Co.	....	437,135	....
	East End Pass. Ry. Co.	....	437,135	....
	Vallamount Trac. Co.	....	582,846	....
	Montoursville Trac. Co.	....	10,000	....
Mauch Chunk Ht., Pw. & El. Lt. Co.	Lehighton El. Lt. & Pw. Co.	1,592,000	....	13
	Central R. R. of N. J.	....	73,080	....
	Lehigh Valley R. R. Co.	....	599,962	....
New Castle Elec. Co.	New Wilmington M. P.	89,647	....	37
	Pa.-Ohio Elec. Co.	....	4,540,916	....
	Sh. & N. C. Ry. Co.	....	275,211	....
Pennsylvania Pw. & Lt. Co.	Allentown & Reading Trac. Co.	....	702,579	9-13-18-19-39-40-41
	Lehigh Valley Trans. Co.	....	48,720,712	45-46-47-48-49-54
	Easton Trans. Co.	....	1,734,200	55-60-64
	Stroudsburg Trac. Co.	....	523,190	....
	Eastern Pa. Ry Co.	....	6,929,386	....

ELECTRIC COMPANIES SELLING OR DELIVERING POWER TO ELECTRIC UTILITIES—Continued
Controlled by Holding Companies

Name of Holding Company / Name of Local Company	Name of Utility Receiving Power	Kwh. Delivered to El. Lt. & Pw. Co.	Kwh. Delivered to St. Ry. Co.	Counties (by No.) in which company delivering power furnishes service
	Shamokin & M. C. Trans. Co.		1,531,539	
	Wilkes-Barre & Hazleton Ry. Co.		2,996,200	
	Shamokin & Edgewood St. R. R. Co.		680,606	
	Sunbury, Lewisburg & Milton R. R. Co.		36,000	
	Northumberland Co. Ry. Co.		466,751	
	Sunbury & Selinsgrove Ry. Co.		335,395	
Penna. Pw. & Lt. Co.	Lewisburg, Milton & Watsontown P. R. Co.		322,400	
	Danville & Sunbury Tran. Co		50,117	
	North Branch Transit Co.		1,473,849	
	Berwick & Nescopeck Ry. Co		62,920	
	Magungie E. L., H. & P. Co.	324,238		
	Tatamy ..L., H. & P. Co.	259,470		
	Penna. Ed. Co.	11,510		
	Mauch Chunk H., P. & E. L. Co.	3,790,400		
	Panther Valley E. Co.	2,535,840		
	Schuylkill El. Co. (Girardsville)	4,149,600		
	Schuylkill El. Co. (Mahanoy)	411,136		
	Ringtown Lt. Co.	70,190		
	Citizens El. Co.	719,950		
	Catawissa M. P.	432,960		
	Prospect Rock L. Co.	210,620		
	Scranton El. Co.	21,300		
Penna. Pw. Co.	Wampum M. P.	135,715		37–4
	Elwood City M. P.	1,359,200		
Penna. Edison Co.	Bangor Elec. Co.	213,000		52
	Eastern Transit Co.		4,970,466	
	E. Washington Trac. Co.		258,837	
Schuylkill Elec. Co.	Schuylkill Ry. Co.		2,538,299	19–54
Scranton Elec. Co.	Moscow Elec. Co.	11,220		35–58–40–64
	Scranton Ry. Co.		18,065,976	
H General Gas & Electric Co.				
Edison Lt. & Pw. Co.	York Haven W. & P. Co.	4,160,970		67
	Wrightsville L. H. & P. Co.	393,110		
	Glen Rock L., H. &. P. Co.	1,733,500		
	York Railways		7,068,828	

Metropolitan Ed. Co.	Reading Transit & Lt. Co.		19,689,165	6-36-46-38-15
	Eastern Pa. Ry.		2,499,388	
	Allentown & Read. Trac. Co.		1,815,740	
	Mt. Penn Gravity Ry. Co.		53,150	
	Hamburg G. & E. Co.	2,812,300		
	Berkshire Elec. Co.	2,363,434		
	York Haven W. & P. Co.	7,446,760		
	Annville & Palmyra El. Co.	2,292,600		
	Philadelphia Sub. G. & El. Co.	273,600		
	Boyertown Elec. Co.	1,104,575		
	Blue Mountain El. Co.	520,000		
	Weimer Elec. Co.	293,950		
Sayre Elec. Co.	Waverly Sayre & Athens Tract. Co.		631,940	59- 8
York Haven W. & Pw. Co.	Metropolitan Ed. Co.	9,759,514		67-22-36
	Edison Lt. & Pw. Co.	15,875,325		
	Harrisburg Lt. & Pw. Co.	12,605,900		
	Middletown M. P.	872,750		
	Royalton M. P.	49,910		
	Goldsboro M. P.	43,720		
J Municipal Service Company				
Chester Valley Elec. Co.	West Chester St. Ry. Co.		1,447,440	15
Citizens Lt. & Pw. Co.	Titusville L. & P. Co.	913,500		61
I Juniata Public Service Corp.				
Juniata Pub. Ser. Co.	Middleburg Lt., Ht. & Pw. Co.	1,116,895		34-50-22
L. Pennsylvania Electric Co.				
Corry City Elec. Co.	Spartansburg	54,000		
	Corry & Columbus Trac. Co.		85,000	25
Hanover Pw. Co.	Gettysburg Elec. Co.	2,241,900		1-67
	Hanover & McSherrystown St. Ry. Co.		370,674	
Penn Pub. Ser. Corp.	Center & Clearfield Ry. Co.		425,636	11-14-16-17-20-25
	Somerset St. Ry. Co.		287,500	32-33-56-61-62-65
	Johnstown Trac. Co.		875,080	
	United Trac. Co.		347,000	
	DuBois Trac. Co.		408,000	
	B. & L. E. Trac. Co. (Erie)		6,347,454	
	Northwestern Elec. Ser. Co.			
	Richley Grove		554,545	
	Edinboro		556,510	
	Venango		436,942	
	Meadville		883,294	
	Harmonsburg		402,530	

ELECTRIC COMPANIES SELLING OR DELIVERING POWER TO ELECTRIC UTILITIES—Continued
Controlled by Holding Companies

Name of Holding Company Name of Local Company	Name of Utility Receiving Power	Kwh. Delivered to El. Lt. & Pw. Co.	Kwh. Delivered to St. Ry. Co.	Counties (by No.) in which company delivering power furnisbes service
	Coalport L., H. & P. Co.	201,930	....	....
	Houtzdale L., H. & P. Co.	285,430	....	....
	United L., H. & P. Co.	315,780	....	....
	Conemaugh M P.	571,800	....	....
	White Oak L., H. & P. Co.	133,890	....	....
	Bolivar L., H. & P. Co.	278,250	....	....
	Jefferson Elec. Co.	2,579,100	....	....
	Rockwood L., H. & P Co	241,500	....	....
	Berlin M P.	221,150	....	....
	Hooversville M. P.	134,700	....	....
	Leperville Elec. Co.	10,474	....	....
	Wayside Elec. Co.	65,490	....	....
	Sykesville Elec. Co.	103,208	....	....
	Big Run Elec. Co.	127,321	....	....
	Corry City Elec. Lt. Co.	2,508,275	....	....
	Union City Elec. Lt. Co.	1,253,880	....	....
	Waterford Elec. Lt. Co.	97,440	....	....
Penn Public Service Corp.	H. D. Carpenter (Yeagerton)	109,590	....	....
	H. D. Carpenter (Harmonsburg)	189,770	....	....
	United Lighting Co. (Albion)	399,779	....	....
	United Lighting Co. (Conneaut)	356,444	....	....
	H. D. Carpenter (Spartansburg)	54,000	....	....
	Girard M. P.	337,100	....	....
M Penn Central Lt. & Pw. Co.				
Penn Central Lt. & Pw. Co.	Lilly L., H. & P. Co.	173,105	....	7-11-31-44
	Citizens L., H. & P. Co.	578,670	....	....
	Jackson L., H. & P. Co.	336,600	....	....
	Summerbill M. P.	78,660	....	....
	Brown Twp. L., H. & P. Co.	140,710	....	....
	Blacklick L. & P. Co.	83,980	....	....
	Altoona & L. V. E. R. R. Co. (Altoona)	....	705,400	....
	Altoona & L. V. E. R. R. Co. (Tyrone)	....	8,530	....
	Northern Cambria Ry. Co.	....	627,820	....
	Lewistown & Reedsville E. Ry. Co.	....	1,897,826	....
Yeagertown W. P. Co.	Penn Central L. &. P. Co.	873,930	....	44

N Penna. Water & Power Co.				
Pa. Water & Pw. Co.	Con. G. & E. L. & P. Co. of Bal.	248,547,200	....	67
	Edison Elec. Co. of Lancaster	85,992,800	....	....
O Philadelphia Electric Co.				
Phila. Electric Co.	Phila. Sub. Co. (Andalusia, Pa.)	5,893,900	....	51–23–46
	Phila. Sub. Co. (Jenkintown & W. G.)	-8,257,900	....	....
	Counties G. & E. Co. (Lansdowne)	2,195,700	....	....
P Republic Railway & Lt. Co.				
Shenango Valley El. Lt. Co.	Shenango Valley Trac. Co.	....	1,663,520	43
Zelienople Lt. & Pw. Co.	Zelienople M. P.	272,900	....	10
Q United Gas & Electric Corp.				
Edison Elec. Co. of Lanc.	Brownstone Elec. Co.	80,100	....	36
	Intercourse Elec. Co.	522,960	....	....
	Conestoga Valley El. Co.	123,400	....	....
	Farmers El. Co.	190,440	....	....
	Oxford El. Co.	1,433,300	....	....
	Conestoga Trac. Co.	....	18,127,030	....
	Lancaster & York Furnace St. Ry. Co.	....	918,900	....
Harrisburg Lt. & Pw. Co.	York Haven	159,540	....	22
	United Elec. (Lemoyne)	18,060	....	....
	Hummelstown W. & P. Co.	700,247	....	....
	Harrisburg Ry. Co.	....	3,764,400	....
* Lancaster El. L., H. & P. Co.	Edison Elec. Co. of Lancaster	1,950,050	....	36
R United Gas Improvement Company				
Counties Gas & Elec. Co.	Phila. & Western Ry. Co.	....	8,501,000	15–23–46
	Reading Transit & Lt. Co.	....	4,164,850	....
	Phila. & West Chester Tract. Co.	....	68,589	....
S United Ry. Investment Co.				
Duquesne Light Co.	Penna. Lt. & Pw. Co.	8,578,439	....	1- 4–10–65
	West Penn Pw. Co.	3,324,294	....	....
	United Elec. Co.	3,373,150	....	....
	Harmony Elec. Co.	12,580,936	....	....
	Pittsburgh Beaver St. Ry. Co.	....	829,100	....
	Beaver V. Trac. Co.	....	4,308,451	....
	Harmony Elec. Co.	....	12,580,936	....
	Pittsburgh Rys. Co.	....	210,420,721	....

TOTALS:

Kwh. Sold to Electric Power Companies	573,644,392
Kwh. Sold to St. Railway Companies	468,600,315
	1,042,244,707

Note: Of this total 284,547,200 Kwh. were delivered beyond the State Borders.

ELECTRIC COMPANIES SELLING OR DELIVERING POWER TO ELECTRIC UTILITIES
Local Companies

Name of Local Company	Name of Utility Receiving Power	Kwh. Delivered to El. Lt. & Pw. Co.	Kwh. Delivered to St. Ry. Co.	Counties (by No.) in which company delivering power furnishes service
Bangor Electric Co.	State Belt Trac. Co.	....	356,362	48
	Bangor & Portland Trac. Co.	....	107,659	....
	Northampton Trac. Co.	....	276,919	....
Bechtelville Mun. Plant	Bally Mun. Plant	117,000	....	6
Boyertown Electric Co.	Bechtelsville M. P.	210,340	....	6–16
Breckenridge Lt. & Pw. Co.	Breckenridge M. Pl.	1,236,820	....	1
Chambersburg M. P.		....	....	28
Clymer Pw. Co.	Lehigh Paper Mills	1,034,300	....	48
	Phila. & Easton Transit Co.	....	1,777,800	....
Delta Water Pw. Co.	Delta Elec. Pw. Co.	28,657	....	67
	Chanceford L., H. & P. Co.	1,110	....	....
Eagles Mere Lt. Co.	Citizens El. L. & Pw. Co. (Hughesville)	313,400	....	57
Erie County Elec. Co.	Northwestern Elec. Ser. Co.	13,517,000	....	....
Glen Rock El. Lt. & Pw. Co.	New Freedom M. P.	733,270	....	67
	Deer Creek W. & P. Co.	158,681	....	....
Harmony Elec. Co.	Ohio Harmony El. Co. (Ohio)	1,293,840	....	1– 4–10–37
	Pittsbg. H. & B. & N. C. Ry. Co.	....	12,402,747	....
	Pittsbg. Marrs., & Butler Ry. Co.	....	3,800,000	....
Hamburg Gas & Elec. Co.	Topton Elec. Lt. & Pw. Co. (Richmond)	867,200	....	6
	Topton Elec. Lt. & Pw. Co. (Maxatawny)	12,720	....	....
	Berks Lehigh Elec. Co.	879,920	....	....
Mercer County L., H & P. Co.	Kinsman Elec. Co. (Ohio)	73,866	....	43
Meyersdale L., H. & P. Co.	Garrett E. L., H. & P. Co.	79,852	....	56
	Citizens L., H. & P. Co. (Elk Lick)	367,088	....	....
Montoursville El. Lt. Co.	Montoursville Pass. Ry. Co.	....	104,550	41
Natrona Lt. & Pw. Co.	Breckenridge L. & P. Co.	4,079,374	....	1
	Tarentum, Breckenridge, & Butler St. Ry. Co.	....	340,170	....
New Freedom N. P.	Railroad E. L. & P. Co.	39,370	....	67
Palmerton Lt. Co.	Penna. Pw. & Lt. Co.	738	....	13

Pennsburg M. P.	E. Greenville Elec. Co.	361,090	....	46
	Palm Elec. Co.	38,165	....	....
	Red Hill Elec. Co.	75,838	....	....
	Green Lane Elec Co.	97,956	....	....
Pequea Elec. Co.	Lancaster & York Furnace St. Ry. Co.	....	322,300	36
Phila. Hydro-Elec. Co.	Philadelphia Rapid Transit Co.	....	10,000,000	51
Phoenix Water Pw. Co.	Reading Trans. & Lt. Co.	....	2,904,700	46
Raystown Water & Pw. Co.	Mar lesburg L., H. & Pw. Co.	108,000	....	7-31-44
	Huntingdon & Juniata Ry Co.	....	150,000	....
Topton El. Lt. & Pw. Co.	Weisenberg Twp. E. L. & P. Co.	9,240	....	6
	Kutztown Mun. Plant	582,240	....	....
Titusville Lt. & Pw. Co.	Titusville Trac. Co.	....	135,150	20-61
Waterford Elec. Co.	Waterford Twp. El. L. & Pw. Co.	15,917	....	25
Windber Elec. Co.	Paint Elec. Co.	89,000	....	56
	Sealp Level Elec. Co.	109,500	....	....
	Rockingham Lt., H. & Pw. Co.	1,348,600	....	....

TOTALS:

Kwh. Sold to Electric Power Companies	27,879,692
Kwh. Sold to Electric Railway Companies	32,678,357
	60,558,049

Note: A small amount of this power is delivered beyond the State border (Included in the 284,547,200 kwh. noted in total delivered beyond the State borders by Holding Companies.)

ELECTRIC POWER COMPANIES—PURCHASING OR RECEIVING POWER
Controlled by Holding Companies

Name of Holding Company Name of Local Company	Kwh. Purchased	Name of Utility from whom purchased	Counties (by No.) in which Co. purch. power furnishes service
A Allentown & Reading Trac. Co.			
Fleetwood & Kutztown E. L., H. & P. Co.	1,845,000	Metropolitan Edison Co.	6
B American Electric Power Co.			
Home Electric L. & Stm. Htg. Co.	8,630	Penn Central Lt. & Pw. Co.	31– 7
Chester Co. Lt. & Pw. Co.	1,151,980	Wilmington & Phila. Trac. Co.	15
C American Gas Company			
E. Penna. Gas & Elec. Co.	5,893,900	Philadelphia Electric Co.	9
New Hope Electric Co.	41,498	New Jersey Pw. & Lt. Co.	9
Phila. Sub. Gas & Elec. Co.	9,427,380	Metropolitan Ed. Co.	9–15–46
		Lansdale Boro.	....
		Philadelphia Elec. Co.	....
		Lehigh Valley Trac. Co.	....
D American Water Wks & Elec. Co.			
Greene Twp. Elec. Co.	3,640	Chambersburg Mun. Plant	28
Hamilton Elec. Co. (Potomac P. S. Co.)	712	Chambersburg Mun. Plant	28
Waynesboro Elec. Co.	4,059,961	Potomac Pub. Ser. Co.	28
West Penn Pw. Co.	1,514,105	Duquesne Light Co.	1–10–30–16
		Pittsburgh Railways	63–65– 3–26
F Eastern Pa. Pw. & Ry. Co.		Ohio Power Co., Ohio	....
Eastern Pa. L., H. & P. Co.	6,327,591	Pennsylvania Pw. & Lt. Co.	19–54
		Metropolitan Ed. Co.	....
		Phila. & Reading Coal & Iron Co.	....
East Penn Elec. Co.	663,180	Susquehanna Collieries	22–54
Pine Grove E. L., H. & Pw. Co.	596,800	Eastern Pa. L., H. & Pw. Co.	54
E Consolidated Utilities Co.			
United Lighting Co.	756,234	Northwestern Elec. Ser. Co.	25–20
G Electric Bond & Share Company			
Anthracite Power Co.	18,121	Wilkes-Barre & Hazleton Ry. Co.	40
Coopersburg E. L., H. &. P. Co.	152,760	Lehigh Valley Tran. Co.	39
E. Greenville E. L., H. & P. Co.	....		46
Excelsior El. Lt. & Pw. Co.	1,793,450	Lehigh Valley Trans. Co.	46
Lackawanna & Wyoming Valley P. Co.	340,315	Scranton Elec. Co.	35–40
Houtzdale E. L. & P. Co.	257,780	Public Service Corp.	17
Lehighton El. Lt. & Pw. Co.	1,597,500	Mauch Chunk H., P. & E. L. Co.	13
Mauch Chunk H., P. & E. L. Co.	3,790,400	Pennsylvania Pw. & Lt. Co.	13
Magungie El. Lt., H. & P. Co.	324,238	Pennsylvania Pw. & Lt. Co.	39

Millville El. Lt. Co.	276,000	Javaud & Lovigns Silk Co.	19
New Castle Elec. Co.	65,466,515	Penna.-Ohio Pw. & Lt. Co.	37
G Electric Bond & Share Co.			
Panther Valley Elec. Co.	2,535,840	Pennsylvania Pw. & Lt. Co.	13-54
Palm El. L. & Pw. Co.	75,000	Pennsburg Mun. Plant	46
Pennsylvania Pw. & Lt. Co.	88,441,769	Lehigh Valley Transit	9–13–18–19–39–40–41–45–46–47–48–49–54 55–60–64
		Pennsylvania Ed. Co. (Stroudsburg)	
		Pennsylvania Ed. Co. (Butztown)	
		Milton Mfg. Co.	
		Bethlehem Steel	
		Palmerton Lt. Co.	
		Lawrence Port. Cement Co.	
		Eagle Silk Co.	
Pennsylvania Power Co.	12,411,000	Pennsylvania-Ohio P. & L. Co.	37 -4
Ringtown L., H. & Pw. Co.	60,000	Pennsylvania Pw. & Lt. Co.	54
Schuylkill Elec. Co.	4,560,736	Pennsylvania Pw. & Lt. Co.	19–54
Scranton Elec. Co.	7,367,896	Wilkes-Barre Co.	35–58–40–64
		D. L. & W. R. R. Co.	
		Pennsylvania Coal Co.	
		L. & W. V. R. R. Co.	
Topton Elec. Lt. & Pw. Co.	867,200	Hamburg Gas & Elec. Co.	6
H General Gas & Electric Co.			
Edison Lt. & Pw. Co.	12,693,989	York Haven W. & Pw. Co.	67
Gettysburg Elec. Co.	2,241,900	Hanover Pw. Co.	1
Metropolitan Ed. Co.	10,326,532	York Haven W. & Pw. Co.	6–36–46–38–15
		Phila. Sub. G. & E. Co.	
		Reading Transit & Lt. Co.	
		Eastern Pa. Ry. Co.	
Weimer El. L. & Pw. Co.	293,950	Metropolitan Ed. Co.	38
York Haven W. & P. Co.	14,981,306	Metropolitan Ed. Co.	22–36–67
		Edison Lt. & Pw. Co.	
		Bethlehem Steel Co.	
I Juniata Public Service Corp.			
Dalmatia Lt. Co.	25,495	Javaud & Lavigne Silk Co.	49
Juniata Pub. Ser. Co.	149,160	United Elec. Co.	34–50–22
Middleburg L. H. &. Pw. Co.	1,116,895	Juniata Pub. Ser. Co.	55
J Municipal Service Company			
Chester Valley Elec. Co.	13,109,705	Phila. Sub. Co.	15
Citizens Lt. & P. Co.	11,967,033	Citizens Trac. Co.	61

ELECTRIC POWER COMPANIES—PURCHASING OR RECEIVING POWER
Controlled by Holding Companies

Name of Holding Company Name of Local Company	Kwh. Purchased	Name of Utility from whom purchased	Counties (by No.) in which Co. purch. power furnishes service
L Pennsylvania Electric Co.			
Citizens L., H. & Pw. Co.	367,088	Meyersdale E. L., H. & Pw. Co.	56
Concord Twp. Pw. Co.	5,100	Corry City El. Lt. Co.	25
Corry City Elec. Co.	2,562,307	Erie Lt. Co.	25
Home Power Co.	400	Erie Lt. Co.	25
L Pennsylvania Electric Company			
Intercourse Elec. Co.	600,000	Edison Elec. Co.	36
Penn Public Service Corp.	13,517,000	Erie County Elec. Co.	61-62-16-25-20-56-11-65-32-17-14-33
Union City Elec. Co.	2,035,580	Erie Lt. Co.	25
Wayne Twp. Pw. Co.	350	Corry City El. Lt. Co.	25
M Penn Central Lt. & Pw. Co.			
Penn Central Lt. & Pw. Co.	873,930	Yeagerstown	11-44- 7-31
	10,860	Am. Ry. Co.	....
Standard Pub. Ser. Co.	69,093	Standard Refractories Co.	7
N Penna. Water & Pw. Co.			
Penna. Water & Pw. Co.	204,900	Consolidated Gas & E. L. & P. Co. of Baltimore	67
P Republic Ry. & Lt. Co.			
Shenango Valley E. L. Co.	27,990,500	Pa.-Ohio Pw. & Lt. Co.	43
Zelienople Lt. & Pw. Co.	424,999	Pennsylvania Pw. Co.	10
Q United Gas & Elec. Corp.			
Berkshire Elec Co.	2,363,694	Metropolitan Ed. Co.	6
Edison Elec. Co. of Lancaster	85,992,800	Penna. W. & P. Co.	36
	1,950,050	Lancaster El. L., H. & P. Co.	22
Harrisburg Lt. & Pw. Co.	12,605,900	York Haven W. & P. Co.	....
	2,800	Bethlehem Steel Co.	....
R United Gas Improvement Co.			
Counties Gas & Elec. Co.	2,195,700	Delaware County Elec. Co.	15-23-46
S United Railway Investment Co.			
Duquesne Lt. Co.	6,920,939	Allegheny Co. Stm. Htg. Co.	1- 4-10-65
	8,504,939	West Penn Pw. Co.	....
	12,792	Beaver Valley Trac.	....
	657,080	Westinghouse El. Mfg. Co.	....
	329,085	Harmony Elec. Co.	....

Kwh. Purchased 76,631,703

NOTE: Of this total 342,047,831 kwh. is obtained from Prime Power Sources beyond the State's Borders.

ELECTRIC POWER UTILITIES IN PENNSYLVANIA
ELECTRIC POWER COMPANIES—PURCHASING OR RECEIVING POWER
Local Companies

Name of Local Company	Kwh. Purchased	Name of Utility from whom purchased	Counties (by No.) in which Co. purch. Power furnishes service
Abington Electric Co.	740 276	Scranton & Binghampton R. R. Co.	35
Allaire Lt. & Pw. Co.	....	Colonial Steel Co.	4
Annville & Palmyra E. L. Co.	2,275,600	Metropolitan Ed. Co.	38
Bailey Municipal Plant	117,000	Bechtelville	6
Bakertown Lt., Ht. & Pw. Co.	240,000	Sterling Coal Co.	....
Berks Lehigh Co.	38,340	Hamburg Gas & El. Co.	39- 6
Berlin Municipal Plant	21,615	Penn Pub. Ser. Corp.	56
Bechtelville Municipal Plant	230,000	Boyertown Elec. Co.	6
Bernville Lt., Ht. & Pw. Co.	7,500	Blue Mountain Elec. Co.	5
Birdsboro Elec. Co.	....	Birdsboro Steel Co.	6
Black Lick L., H. & Pw. Co.	90,839	Penn Central Lt. & Pw. Co.	11
Blue Mountain Elec. Co.	493,000	Metropolitan Ed. Co.	6-38-22
Bolivan L., H. & P. Co.	278,250	Penn Public Ser. Corp.	32
Boyertown Elec. Co.	1,105,580	Metropolitan Ed. Co.	6-46
Brownstone El. L. & Pw. Co.	112,000	Edison El. Co. of Lancaster	36
Bradford Elec. Co.	3,355,800	Orleans El. Lt. & Pw. Co., N. Y.	42
Brown Twp. L., H. & Pw. Co.	137,400	Penn Central Lt. & Pw. Co.	44
Brackenridge Lt. & Pw. Co.	4,079,374	Natrona Lt. & Pw. Co.	1
Catawissa Mun. Plant	422,920	Pa. Pw. & Lt. Co.	19
Center Elec. Co.	68,970	Keystone Pw. Co.	14
Citizens Elec. Co. Valley View	80,120	Phila. & Reading C. & I. Co.	54
Citizens Elec. L. &. P. Co., Hughesville	344,900	Eagles Mere Lt. Co.	41
Citizens Elec. Co. of Lewisburg	719,950	Pa. Pw. & Lt. Co.	60
Clover Elec. Co.	1,835,010	Ebensburg Coal Co.	11
Clarendon Elec. Lt. & Pw. Co.	415,800	Warren St. Ry. Co.	62
Conemaugh Mun. Plant	522,590	Penn Pub. Ser. Corp.	11
Coalport Lt., Ht. & Pw. Co.	201,930	Penn Pub. Ser. Corp.	17
Conneaut Lake E. L. & Pw. Co.	30,722	Northwestern Elec. Ser. Co.	20
Conestoga Valley Elec. Co.	132,400	Edison Elec. Co. of Lancaster	36
Cresson Elec. Lt. Co.	979,050	Penn Central Lt. & Pw. Co.	11
Cumberland Valley Lt. & Pw. Co.	792,000	United El. Co.	1-21-67
Dunbar Elec. Co.	....	American Manganese Mfg. Co.	26
		West Penn Pw. Co.	....
Easton M. P.	....	Pennsylvania Ed. Co.	....
Elwood City Mun. Plant	1,359,200	Pennsylvania Pw. Co.	37
Everett Lt., Ht. & Pw. Co.	134,789	Cottage Planing Mill Co.	5

ELECTRIC POWER COMPANIES—PURCHASING OR RECEIVING POWER
ELECTRIC POWER UTILITIES IN PENNSYLVANIA—Continued
Local Companies

Name of Local Company	Kwh. Purchased	Name of Utility from whom purchased	Counties (by No.) in which Co. purch. Power furnishes service
Farmers Elec. Co. of Martic Twp.	194,080	Edison Elec. Co. of Lanc.	36
Garland Mfg. Co.	541,600	New Castle Elec. Co.	37
Garrett El. Lt., Ht & Pw. Co.	79,852	Meyersdale E. L., H. & P. Co.	56
Gallitzin Elec. Co.	380,120	Penn Central Lt. & Pw. Co.	11
Girard Municipal Plant	....	Northwestern Elec. Ser. Co.	25
Glen Rock E. L. & P. Co.	1,733,500	Edison Lt. & Pw. Co.	67
Goldsboro Mun. Plant	43,720	York Haven W. & P. Co.	67
Greencastle Lt., Ht., Fuel & Pw. Co.	501,000	Waynesboro Elec. Co.	28
Gratz Lt. & Pw. Co.	21,828	E. Pa. Pw. & Ry. Co.	22
Green Lane Lt., Ht. & Pw. Co.	....	Pennsburg Mun. Plt.	46
Harvey Lake Light Co.	59,960	Luzerne Gas & Elec. Co.	66–40
Harmony Elec. Co.	25,921,872	Duquesne Lt. Co.	1–10– 4–37
Hastings Elec. Co.	298,666	Penn Central Lt. & Pw. Co.	11
Hatfield M. Plant	....	Excelsior El. Lt., P. & Gas Co.	46
Hamburg G. & E. Co.	2,812,300	Metropolitan Ed. Co.	6
Harley D. Carpenter	320,718	Northwestern Elec. Ser. Co.	20
		Corry City El. Lt. Co.	....
Hershey Elec. Co.	1,635,945	Hershey Chocolate Co.	22
Hummelstown W. & P. Co.	696,946	Harrisburg Lt. & Pw. Co.	22
Jackson Lt., Ht. & Pw. Co.	330,900	Penn Central Lt. & Pw. Co.	11
Kurtztown Mun. Plant	600,000	Topton El. L. & Pw. Co.	6
Langhorne El. Lt. & Pw. Co.	616,140	E. Penna. G. & El. Co.	9
Lilly Lt., Ht. & Pw. Co.	167,142	Penn Central Lt. & Pw. Co.	11
Lower Chanceford El. L., H. & P. Co.	12,000	Delta Water Pw. Co.	67
Logan Lt., Ht. & Pw. Co.	....	Logan Coal Co.	11
Ludlow G. & E. Co.	79,680	J. G. Curtis Leather Co.	42
Marklesburg Lt. & Pw. Co.	23,746	Raystown Water Pw. Co.	31
Meadville Mun. Plant	305,600	Northwestern El. Ser. Co.	20
Mercersburg, Lehmaster & Markes E. Co.	33,500	....	28
Mifflinburg M. Plant	....	Half Penny & Grove	60
Middleton Mun. Plant.	....	York Haven Trans. Co.	22
Montgomery & Muncy E. L., H. & P. Co.	785,900	Montgomery Table Works	41
Moscow Elec. Co.	11,220	Scranton Elec. Co.	35
Newmanstown E. L. & P. Co.	390,016	Ephrata & Lebanon Trac. Co.	38
New Kingston E. L., H. & P. Co.	22,919	United Elec. Co.	21
New Wilmington Mun. Plt.	45,000	....	37

New Freedom M. P.	733,270	Glen Rock El. L. & P. Co.	67
Nicholson Lt., Ht. & Pw. Co.	143,893	Scranton, Montrose & Bing. Ry. Co.	66
Niantic El. Lt. & Pw. Co.	30,589	Balley	6-46
Norristown Mun. Plt.	257,200	Counties Gas & Elec. Co.	46
Orrtanna El. Lt. & Pw. Co.	53,300	Gettysburg Elec. Co.	1
Palmerton Lt. Co.	1,388,860	New Jersey Zinc Co.	13
Paint Elec. Co.	89,000	Windber Elec. Co.	56
Pequea Elec. Co.	855,700	Edison Elec. Co. of Lanc.	36
Penn Twp. Pw. Co.	64,074	Westmoreland Coal Co.	65
Pioneer Elec. Co.	35,750	Pa. Water & Pw. Co.	36
Pike County Lt. & Pw. Co.	296,910	Orange Co. Pub. Ser. Corp., N. Y.	52
Portage Lt. & Pw. Co.	571,870	Penn Central Lt. & Pw. Co.	11
Prospect Rock El. Lt., H. & P. Co.	210,620	Pennsylvania Pw. & Lt. Co.	40
Prompton Elec. Co.	10,378	Honesdale Con. L., H. & P. Co.	64
Railroad El. Lt. & Pw. Co.	39,155	New Freedom E. L. & P. Co.	67
Red Hill El. Lt. & Pw. Co.	74,620	Pennsburg Mun. Plant	46
Rockwood Elec. Co.	241,500	Penn Pub. Ser. Corp.	56
Rockingham L., H. & P. Co.	1,348,600	Winber Elec. Co.	56
Royalton Mun. Plant	49,910	York Haven Trans. Co.	22
Scrap Level El. Co.	109,500	Winber Elec. Co.	11
Sewickley Twp. Pw. Co.	27,893	Westmoreland Coal Co.	65
Sheffield El. Lt. & Pw. Co.	772,000	Warren St. Ry. Co.	62
Sommerhill Mun. P.	45,104	Penn Central Lt. & Pw. Co.	11
Stoufferstown Elec. Co.	14,586	Chambersburg Mun. Plant	28
Tatamy Lt., Ht. & Pw. Co.	385,897	Pennsylvania Pw. & Lt. Co.	48
Titusville Lt. & Pw. Co.	913,500	Citizens Lt. & Pw. Co.	20-61
Tri-County Elec. Co.	489,890	Edison Elec. Co. of Lancaster	36
United Lt., Ht. & Pw. Co.	315,780	Penn Public Ser. Corp.	56
United Elec. Lt. Co.	3,360,400	Duquesne Lt. Co.	1
Waterford Elec. Lt. Co.	119,820	Erie Lighting Co.	25
Wayside El. Co.	46,405	Penn Pub. Ser. Co.	56
Wampum Mun. Plant	....	Pennsylvania Pw. Co.	37
Weisenberg El. Lt. & Pw. Co.	16,300	Topton El. Lt. & Pw. Co.	39- 6
Wellersburg Elec. Co.	164,700	Trostburg Ill. & Mfg. Co.	56
White Oak Lt., Ht. & Pw. Co.	133,890	Penn Pub. Ser. Corp.	56
Winber Elec. Co.	2,586,300	Berwin White Coal Mining Co.	56
Winola Elec. Co.	1,511	Scranton, Montrose & Bing. Ry. Co.	46
Wrightsville Lt. & Pw. Co.	393,110	Edison Lt. & Pw. Co.	67
Zelienople Municipal Plant	214,123	Zelienople Lt. & Pw. Co.	10

Kwh. Purchased 409,730,982

NOTE: A small amount of this power is received from Power sources beyond the State borders (Included in the 342,047,831 kwh. noted in total Received from Prime Power Sources beyond the State borders by Holding Companies.)

NO. OF CUSTOMERS AND K.W.H. USED IN COUNTIES

No.	Name	Power		Comm. Lt. & Pw.		Domestic		Mun. St. Lt. Kwh.	Total Kwh. (Inc. St. Ry. & Pub. Util.)
		No. Cust.	Kwh.	No. Cust.	Kwh.	No. Cust.	Kwh.		
1.	Adams	110	2,079,561	492	468,696	2,527	465,627	180,534	3,194,418
2.	Allegheny	1,382	57,832,865	26,959	366,998,314	174,288	51,346,094	26,875,522	794,819,326
3.	Armstrong	204	27,152,000	1,001	1,525,400	3,120	3,476,403	913,720	33,067,523
4.	Beaver	96	6,572,000	2,976	41,932,600	13,589	4,544,535	915,720	71,462,452
5.	Bedford	36	291,492	186	309,730	1,078	121,176	66,170	788,587
6.	Berks	943	3,445,312	4,321	822,510	21,498	1,990,508	340,298	9,027,088
7.	Blair	526	38,495,650	2,981	3,583,966	20,216	5,412,169	620,000	13,265,715
8.	Bradford	123	1,001,315	619	341,728	3,138	1,246,305	290,574	3,511,862
12.	Cameron	10	....	45	....	490	377,240	27,760	405,000
13.	Carbon	237	1,947,834	593	1,030,761	7,866	2,298,226	521,016	14,389,859
14.	Center	462	34,164,732	1,515	1,546,132	7,448	3,088,310	647,647	39,440,161
15.	Chester	845	10,592,906	2,890	1,252,601	11,670	1,218,143	627,505	15,658,595
16.	Clarion	30	5,670,000	267	558,050	443	178,920	132,000	6,538,970
17.	Clearfield	289	15,587,569	760	590,942	7,702	3,610,133	179,517	21,289,157
18.	Clinton	60	1,088,322	580	837,318	3,876	1,026,678	199,334	3,568,097
19.	Columbia	134	11,042,225	788	947,506	4,632	1,102,826	279,506	15,117,269
20.	Crawford	273	8,773,188	1,255	852,878	6,150	2,058,707	773,600	15,645,552
21.	Cumberland	276	7,035,928	774	626,058	7,106	2,953,402	148,398	15,431,268
22.	Dauphin	579	24,412,905	15,576	6,923,515	20,307	5,969,016	4,326,780	46,548,743
23.	Delaware	730	....	4,337	....	21,387	22,500	....	22,500
24.	Elk	96	9,600,000	391	461,224	1,617	485,100	428,141	10,974,465
25.	Erie	1,916	41,054,905	4,358	5,321,739	24,389	10,582,899	2,618,522	83,201,575
27.	Forest								
28.	Franklin	124	4,728,614	622	853,961	5,362	1,203,087	362,470	7,709,232
29.	Fulton								
30.	Greene	66	9,480,000	269	443,850	865	331,728	172,000	10,427,578
31.	Huntingdon	129	55,044,511	463	2,114,235	3,793	1,120,895	926,457	60,661,155
32.	Indiana	227	13,655,000	101	42,350	4,285	2,417,930	58,000	16,173,280
33.	Jefferson	103	5,022,144	601	656,830	3,194	1,842,649	401,860	11,481,844
34.	Juniata	24	500,000	39	....	668	162,154	20,000	682,154
35.	Lackawanna	1,318	60,506,026	6,513	10,137,662	31,980	6,788,423	2,482,890	112,647,476
36.	Lancaster	1,899	40,245,112	3,325	9,090,518	20,143	2,026,060	12,670	76,536,120
37.	Lawrence	274	58,782,060	1,509	2,151,179	10,462	2,960,679	928,006	72,720,426

38. Lebanon	318	1,391,769	1,409	335,605	7,283	719,169	36,378	2,482,921
39. Lehigh	1,006	90,385,185	4,581	5,909,377	16,728	3,800,588	1,990,294	151,895,073
40. Luzerne	1,638	143,439,083	8,917	10,418,301	39,526	9,102,710	4,472,890	171,860,313
41. Lycoming	439	11,642,213	1,439	2,675,670	13,345	3,248,548	715,986	22,521,160
42. McKean	95	13,127,218	407	1,708,271	1,751	1,563,826	877,962	6,341,869
43. Mercer	368	18,170,999	1,880	1,860,841	8,021	1,884,048	735,449	30,492,025
44. Mifflin	114	9,787,681	579	859,000	3,238	1,084,480	209,000	14,853,567
47. Montour	44	4,748,000	294	323,700	921	304,462	170,000	5,874,866
48. Northampton	870	43,957,992	4,539	2,607,989	16,992	2,563,081	1,374,200	62,470,885
49. Northumberland	369	36,665,487	2,609	3,490,400	15,231	2,675,154	2,498,600	48,702,332
50. Perry	81	680,000	364	33,910	2,000	550,264	96,135	2,477,214
51. Philadelphia	12,008	365,830,151	53,816	116,040,046	151,999	53,229,434	42,720,409	824,741,942
52. Pike	5	....	......	156,500	230	140,410	....	269,910
53. Potter	25	356,500	28	....	255	255,000	69,590	83,681,090
54. Schuylkill	774	50,921,402	2,000	2,944,089	23,549	7,075,804	2,147,348	664,658
55. Snyder	31	....	......	....	539	....	....	1,116,895
56. Somerset	312	10,032,558	714	920,532	6,446	1,559,494	386,870	17,170,139
57. Sullivan	18	105,000	49	41,740	1,378	320,351	51,000	1,161,263
58. Susquehanna	83	2,239,284	619	518,570	2,911	546,883	187,000	3,591,737
59. Tioga	118	860,366	190	40,326	1,953	777,967	129,840	1,808,499
60. Union	57	227,045	......	302,872	1,633	302,972	62,991	1,328,876
61. Venango	246	5,341,375	1,188	2,722,069	4,657	1,258,498	648,502	10,833,944
62. Warren	150	7,263,000	428	380,000	2,951	2,524,370	338,000	10,505,170
63. Washington	757	104,695,000	4,215	7,254,750	12,074	4,396,400	1,884,000	119,431,430
64. Wayne	106	763,124	365	657,432	1,440	505,048	94,032	2,052,900
65. Westmoreland	777	107,463,437	5,123	13,957,315	17,775	6,948,965	3,127,000	131,750,389
66. Wyoming	9	64,096	......	....	507	96,018	636	161,750
67. York	816	10,151,904	3,114	3,535,231	12,467	3,555,257	1,020,066	156,986,932
9. Bucks	266	2,457,563	1,001	408,127	6,962	800,076	391,360	5,297,028
10. Butler	257	38,101,987	1,261	2,038,660	5,078	1,847,025	431,938	43,612,018
11. Cambria	599	38,016,137	4,271	3,822,074	20,965	8,430,457	1,852,502	55,848,891
26. Fayette	443	61,170,000	2,207	3,883,182	8,056	2,998,380	1,318,114	69,915,109
45. Monroe	105	7,055,000	456	462,800	24,819	522,144	106,000	8,669,334
46. Montgomery	612	52,825,617	2,779	7,215,816	17,887	4,158,707	2,621,285	114,171,059
TOTAL	37,437	1,796,740,326	197,888	659,946,757	874,456	256,719,510	119,179,454	3,771,151,809

INCREASE IN PLANT CAPACITIES
1922—1923
As Reported in Public Service Commission's Report for December 31, 1923

	December 31, 1922 (Questionnaire)	December 31, 1923 (P. S. C. Report)	Increase
American Gas Company			
Luzerne County Gas & Electric Co. ..	22,500 kw.	47,500 kw.	25,000 kw.
Philadelphia Sub. Gas & Elec. Co. ..	21,210 kw.	30,000 kw.	8,790 kw.
General Gas & Electric Company			
Metropolitan Edison Company	41,500 kw.	46,500 kw.	5,000 kw.
Electric Bond & Share Company			
Lycoming Edison Co.	11,900 kw.	21,900 kw.	10,000 kw.
Penn Central Light & Power Co.	25,500 kw.	45,500 kw.	20,000 kw.
Pennsylvania Water & Power Co.	83,500 kw.	111,000 kw.	27,500 kw.
Philadelphia Electric Company	336,230 kw.	387,480 kw.	41,250 kw.
United Gas Improvement Co.			
Counties Gas & Elec. Co.	21,630 kw.	42,250 kw.	20,620 kw.
Total Increase	....	....	158,160 kw.

POWER GENERATED AND PURCHASED BY MUNICIPAL PLANTS

No.	Name	Steam		Oil and Gas			Purchased Power		Total Kwh.
		Cap.	Kwh. Gen.	Kind	Cap.	Kwh. Gen.	From Whom	Kwh.	
1.	Allegheny	.....	....	..	.....	....	....	....	....
2.	Aspinwall	1,300	1,460,000	..	.....	....	....	....	1,460,000
3.	Bally	.....	....	..	.....	....	Bechtelville Mun. Plant	117,000	117,000
4.	Bechtelville	.....	....	..	.....	....	Boyertown El. Co.	323,000	323,000
5.	Berlin	.....	....	..	.....	....	Penn Pub. Ser. Co.	21,615	21,615
6.	Blakeley Boro ...	475	542,696	..	.....	....	....	....	542,696
7.	Brackenridge	.....	....	..	.....	....	Brackenridge L. & P. Co.	1,236,820	1,236,820
8.	Catawissa	.....	....	..	.....	....	Penna. Pw. & Lt. Co.	422,920	422,920
9.	Chambersburg ...	2,500	2,430,350	..	.....	....	....	....	2,430,350
10.	Conemaugh	.....	....	..	.....	....	Penn Pub. Ser. Corp.	522,590	522,590
11.	Confluence	60	....	..	.....	....	....	....	....
12.	Coraopolis	.....	....	G	820	1,696,000	....	....	1,696,000
13.	Danville	150	146,000	..	.....	....	....	....	146,000
14.	Duncannon	100	170,378	..	.....	....	....	....	170,378
15.	E. Greenville	.....	....	..	.....	....	Pa. Pw. & Lt. Co.	....	....
16.	Easton	Plant	abandoned	..	.....	....	....	....	....
17.	Elwood City	.....	....	..	.....	....	Pennsylvania Pw. Co.	1,359,200	1,359,200
18.	Emporium	.....	....	G	375	600,000	....	....	600,000
19.	Ephrata	800	....	..	.....	....	....	....	....
20.	Etna	.....	....	..	.....	....	....	....	....
21.	Ford City	.....	....	G	1,000	3,562,323	....	....	3,562,323
22.	Girard	175	....	..	.....	....	Northwestern E. S. Co.	....	....
23.	Goldsboro	.....	....	..	.....	....	York Haven W. & Pw. Co.	43,720	43,720
24.	Grove City	.....	....	G	510	1,625,000	....	....	1,625,000
25.	Hatfield	.....	....	..	.....	....	Excelsior Lt. & Pw. Co.	....	....
26.	Kulpville	Plant	abandoned	..	.....	....	....	....	....
27.	Kurtztown	.....	....	..	.....	....	Topton El. L. & P. Co.	600,000	600,000
28.	Lansdale	1,500	1,687,610	..	.....	....	....	....	1,687,610
29.	McAlisterville	.....	....	..	.....	....	....	....	....
30.	Meadville	.....	....	..	.....	....	Northwestern E. S. Co.	305,600	305,600
31.	Media	125	225,000	..	.....	....	....	....	225,000
32.	Middletown	.....	....	..	.....	....	York Haven T. Co.	....	....
33.	Mifflinburg	.....	....	..	.....	....	....	....	....
34.	Millvale	Plant	abandoned	..	.....	....	....	....	....
35.	New Freedom	.....	....	..	.....	....	Glen Rock El. L. & Pw. Co.	733,270	733,270
36.	New Wilmington	.....	....	..	.....	....	....	89,647	89,647
37.	Norristown	.....	....	.	.....	....	Counties Gas & El. Co.	257,200	257,200

POWER GENERATED AND PURCHASED BY MUNICIPAL PLANTS—Continued

No.	Name	Steam		Oil and Gas			Purchased Power		Total Kwh.
		Cap.	Kwh. Gen.	Kind	Cap.	Kwh. Gen.	From Whom	Kwh.	
38.	Olyphant	450	....	..	.....	....	....	....	....
39.	Pecksville	500	....	..	.....	....	....	....	....
40.	Pennsburg	525	....	..	.....	....	....	....	....
41.	Perkasie	460	....	..	.....	....	....	....	....
42.	Pitcairn	.....	....	G	600	1,000,000	....	....	1,000,000
43.	Quakertown	1,000	....	..	.....	....	....	....	....
44.	Royalton	.....	....	..	.....	....	York Haven T. Co.	49,910	49,910
45.	St. Claire	260	....	..	.....	....	....	....	....
46.	Schuylkill Haven .	725	1,114,990	..	.....	....	....	....	1,114,990
47.	Sharpsburg	1,350	1,729,430	..	.....	....	....	....	1,729,430
48.	Summerhill	.....	....	..	.....	....	Penn Cent. L. & Pw. Co.	45,104	45,104
49.	Souderton	.....	....	..	.....	....	....	....	....
50.	Tarentum	1,500	1,856,857	..	.....	....	....	....	1,856,857
51.	Titusville	100	....	..	.....	....	....	....	....
52.	Wampum	.....	....	..	.....	....	Pennsylvania Pw. Co.	135,715	135,715
53.	Watsontown	85	384,000	..	.....	....	....	....	384,000
54.	Weatherly	400	758,670	..	.....	....	....	....	758,670
55.	Zelienople	.....	....	..	.....	....	Zelionople L. & Pw. Co.	256,000	256,000

TOTALS:

	Kw. Capacity	Kwh. Generated or Purchased
Prime Mover—Steam	14,240	12,505,603
Oil or Gas	3,305	8,483,323
	17,545	20,988,926
Purchased Power	......	5,518,934
Total Power Generated and Purchased	. . .	26,507,860

MUNICIPAL PLANTS IN PENNSYLVANIA

Consumers Data

No.	Name	Pop.	County	Kwh. Sales				Customers			
				Power	Comm.	Dom.	St. Lt.	Power	Comm.	Dom.	Total
1.	Allegheny	Not given	Allegheny	......	......	......	......	...	.....	.....	.....
2.	Aspinwall	3,170	Allegheny	......	......	......	......	17	.....	816	833
3.	Bally	387	Berks	......	......	......	......	...	.....	.....	160
4.	Bechtelville	502	Berks	162,500	18,000	19,000	6,500	15	21	107	143
5.	Berlin	1,563	Somerset	......	......	......	......	10	25	265	300
6.	Blakeley Boro	6,564	Lackawanna	......	......	......	77,000	...	.....	.....	.....
7.	Brackenridge	4,987	Allegheny	......	......	......	......	...	.....	....	.....
8.	Catawissa	2,025	Columbia	227,225	68,421	85,962	41,312	11	73	409	493
9.	Chambersburg	13,171	Franklin	670,943	793,052	......	237,250	...	.....	.....	.....
10.	Conemaugh	10,068	Cambria	......	185,442	217,134	120,014	25	1,025	125	1,200
11.	Confluence	1,031	Somerset	......	......	......	......	...	.....	.....	.....
12.	Coraopolis	6,162	Allegheny	......	......	......	......	60	.....	1,500	1,560
13.	Danville	6,954	Montour	......	......	......	146,000	1	.....	.....	.....
14.	Duncannon	1,679	Perry	......	22,582	97,139	36,135	11	.....	354	365
15.	East Greenville	1,620	Berks	......	......	......	......	...	.....	.....	.....
16.	Easton	33,813	Northampton	......	......	......	......	...	.....	.....	.....
17.	Elwood City	8,958	Lawrence	......	......	119,800	13,200	...	.....	1,800	1,800
18.	Emporium	3,036	Cameron	......	......	......	......	10	45	490	545
19.	Ephrata	3,735	Lancaster	......	......	......	......	...	.....	.....	.....
20.	Etna	6,341	Allegheny	......	......	......	......	...	.....	.....	987
21.	Ford City	5,605	Armstrong	......	......	......	......	16	125	640	781
22.	Girard	1,242	Erie	......	......	......	......	...	.....	.....	.....
23.	Goldsboro	477	York	......	38,904	......	4,816	2	.....	103	105
24.	Grove City	4,944	Mercer	......	......	......	......	90	110	900	1,100
25.	Hatfield	830	Montgomery	......	......	......	......	...	.....	.....	.....
26.	Kulpsville	250	Montgomery	......	......	......	......	...	.....	.....	.....
27.	Kurtztown	2,684	Berks	280,560	15,000	256,400	48,000	19	20	557	600
28.	Lansdale	4,728	Montgomery	......	......	......	......	117	141	1,226	1,484
29.	McAlisterville	570	Juniata	......	......	2,654	......	...	.....	.....	.....
30.	Meadville	14,568	Crawford	......	......	......	305,600	...	.....	.....	.....
31.	Media	4,109	Delaware	......	......	......	225,000	...	.....	.....	.....
32.	Middletown	5,920	Dauphin	......	......	......	......	167	278	820	1,264

MUNICIPAL PLANTS IN PENNSYLVANIA—Continued
Consumers Data

No.	Name	Pop.	County	Kwh. Sales				Customers			
				Power	Comm.	Dom.	St. Lt.	Power	Comm.	Dom.	Total
33.	Mifflinburg	1,714	Union	....	....	....	....	...	.....	.....	.
34.	Millvale	8,031	Allegheny	....	....	....	....	...	.....	....	.....
35.	New Freedom	906	York	366,320	173,500	120,000	58,000	...	.....	.....	247
36.	New Wilmington ..	886	Lawrence	....	....	....	....	...	.....	135	135
37.	Norristown	32,319	Montgomery	....	....	....	257,200	...	.....	....	.....
38.	Olyphant	10,236	Lackawanna	....	....	....	....	...	.....	.....	.....
39.	Peckville	3,924	Lackawanna	....	....	....	....	...	.....	.....	.....
40.	Pennsburg	1,404	Montgomery	....	....	....	21,720	...	.....	.....	.....
41.	Perkasie	3,150	Bucks	....	....	....	....	...	.....	.....	.....
42.	Pitcairn	5,738	Allegheny	....	....	620,000	70,000	...	.....	.....	1,165
43.	Quakertown	4,391	Bucks	....	....	....	....	...	.....	.....	.....
44.	Royalton	1,156	Dauphin	....	....	....	....	...	.....	142	142
45.	St. Claire	6,585	Allegheny	....	....	....	....	...	.....	....	.....
46.	Schuylkill Haven ..	5,437	Schuylkill	684,000	60,000	199,620	70,200	50	40	1,109	1,199
47.	Sharpsburg	8,921	Allegheny	....	....	....	....	28	250	1,119	1,397
48.	Sommerhill	890	Cambria	....	35,104	....	10,000	...	.....	.....	148
49.	Souderton	3,125	Montgomery	....	....	....	....	...	.....	.....	.....
50.	Tarentum	8,925	Allegheny	....	174,857	....	108,000	...	.....	.....	.....
51.	Titusville	8,432	Crawford	....	....	....	....	...	.....	....	.....
52.	Wampum	882	Lawrence	....	....	....	....	...	.....	250	250
53.	Watsontown	2,153	Northumberland	....	340,800	....	43,200	...	.....	.....	597
54.	Weatherly	2,356	Carbon	....	698,670	....	60,000	...	15	556	571
55.	Zelienople	3,057	Butler	26,987	65,910	85,231	35,400	10	84	244	338

TOTALS:	Kwh. Sold	No. of Customers
Power Service	2,418,535	659
Commercial Service	2,690,242	2,152
Domestic Service	1,823,040	13,367
Street Lighting	1,994,547	......
	8,926,364	16,478

Note: These totals are approximate as data received from municipal plants was incomplete.

POWER USED BY ELECTRIC RAILWAYS
Properties Controlled by Holding Companies

Index Letter	Name of Holding Co. Name of Local Co.	Steam Generation		Water, Gas or Oil		Purchased Power		Power Used by Ry.	System Peak
		Cap.	Kwh. Gen.	Cap.	Kwh. Gen.	Kwh.	From Whom		
A.	Allentown & Read. T. Co.	.....	....	.....	....	840,000	F. & K. E. L., H. & P. Co.	1,511,500	380
						711,500	Pa. Pw. & Lt. Co.	....	.....
B.	Am. El. Pw. Co.								
	Altoona & L. V. Ry. Co.	3,000	8,750,820	.....	....	705,400	Penn Central L. & P. Co.	10,642,180	3,100
						1,185,960	H. E. L. & Stm. H. Co.	....	.....
	Peoples St. Ry. Co.	.....	....	.....	....	1,088,000	Luzerne Co. G. & E. Co.	1,088,000	435
	Scranton Ry. Co.	.....	....	.....	....	19,173,021	....	19,173,021	.....
	Southern Pa. Tr. Co.	.....	....	.....	....	8,134,576	P. E. Co.	8,134,576	1,910
D.	Am. W. Wks. & E. Co.								
	Alleg. V. St. Ry. Co.	.....	....	.....	....	2,457,948	Alleg. V. Lt. Co.	26,682,496	8,425
						24,224,548	West Penn Pw. Co.	....	.....
	C. G. W. St. Ry. Co.	.....	....	.....	....	1,514,570	Potomac P. S. Co.	1,514,570	750
	Hag. & Fred Ry. Co. of Pa.	.....	....	.....	....	30,000	Potomac P. S. Co.	30,000	100
	Potomac P. S. Co.	.....	....	.....	....	....	....	....	.....
	West Penn Ry. Co.								
F.	E. Pa. Pw. & Ry. Co.								
	E. Pa. Rys. Co.	.....	....	.....	....	3,107,743	Pa. P. & Lt. Co.	3,107,743	1,750
						5,591,024	E. Pa. L. H., & P. Co.	5,591,024	1,450
G.	Electric B. & S. Co.								
	Lehigh V. Tr. Co.	40,812	55,632,234	.....	....	2,867,629	Pa. Ed. Co.	42,692,234	.....
						207,300	Phila. & West. Ry.	....	.....
						50,454,912	Pa. Pw. & Lt. Co.	....	.....
						66,420,606	Sells to 4 Co's.	....	.....
						96,235	Sells to 2 Pri. Co's.	4,123,790	.....
	Williamsport Pass. Ry. Co.	.....	....	.....	....	3,642,790	Lycoming Ed. Co.	....	.....
		.....	....	.....	....	481,000	Jersey Shore E. Co.	....	.....
H.	Gen. Gas & Elec. Co.	.....	....	.....	....	19,687,165	Met. Ed. Co.	26,774,440	5,450
	Oley Valley Ry. Co.					2,904,700	Phoenix W. P. Co.	....	.....
	Reading Tr. & Lt. Co.	.....	....	.....	....	4,681,750	Count. G. & E. Co.	....	.....
						499,175	Misc. other companies	....	.....
J.	Municipal Ser. Co.	8,000	14,517,422	.....	....	11,967,033	Citizens L. & P. Co.	2,550,389	.....
	Citizens Trac. Co.	.....	....	.....	....	....	....	....	.....

POWER USED BY ELECTRIC RAILWAYS—Continued
Properties Controlled by Holding Companies

Index Letter	Name of Holding Co. / Name of Local Co.	Steam Generation Cap.	Steam Generation Kwh. Gen.	Water, Gas or Oil Cap.	Water, Gas or Oil Kwh. Gen	Purchased Power Kwh.	Purchased Power From Whom	Total Power Used by Ry.	System Peak
K.	Pa.-Ohio P. & L. Co.								
	New Castle City Lines	.....	....	.....	....	4,540,916	New Castle El. Co.	1,540,916	1,490
	New Castle & Lowell Ry Co...	.....	....	.....	....	797,994	Pa.-Ohio P. & L. Co.	797,994	300
	Shenango V. Tr. Co.	.....	....	.....	....	1,663,520	Shenango V. El. L. Co. ...	1,663,520	690
L.	Penna. Elec. Co.								
	Dubois Trac. Co.	.....	....	.....	....	408,000	Dubois El. Co.	408,000	130
	Center & Clear. Ry. Co.	.....	....	.....	....	428,950	Penn P. S. Corp.	428,950	300
	N. W. El. Ser. Co.	.....	....	.....	....	13,517,000	Erie Co. El. Co.	13,517,000	3,546
M.	Penn Central L. & P. Co.								
	Lewistown & Reedsville El. Ry. Co.	.....	....	.....	....	1,854,925	Penn Cent. Lt. & Pw. Co. .	1,827,525	900
						27,400	To Pri. Consumers	....	.....
Q.	United G. & E. Corp.								
	Conestoga Tr. Co.	.....	....	.....	....	18,127,030	Ed. El. Co.	18,127,030	.....
S.	United Ry. Inv. Co.								
	Beaver V. Tr. Co.	.....	....	.....	....	4,064,216	Duquesne Lt. Co.	4,064,216	966
	Clairton St. Ry. Co.	.....	....	.....	....	202,954	Carnegie Steel Co.	202,954	25
	Pittsbg. Ry. Co.	.....	....	.....	....	208,450,935	Duquesne Lt. Co.	....	54,641
						27,839	West Penn Pw. Co.		
						1.191,789	Misc. Consumers	207.286,985	.....

TOTALS:	Capacity	Kwh. Generated or Purchased	Kwh. Sold
Prime Movers Steam	51,812	78,900,476	....
Purchased Power	......	407,775,915	....
Power sold to other users	......	....	80,202,238
Totals	51,812	486,676,391	80,202,238
Total Kwh. used for Ry. operation		406,481,053	

POWER USED BY ELECTRIC RAILWAYS OPERATING IN PENNSYLVANIA
Local Properties
Listed in Moody's Manual

No.	Name of Local Co.	Steam Plants No	Steam Plants Cap.	Steam Plants Kwh. Gen	Water, Oil Plants No.	Water, Oil Plants Cap.	Water, Oil Plants Kwh. Gen	Purchased Power Kwh.	Purchased Power From Whom	Total Power	System Peak
1.	Buffalo & L. E. T. Co.	.	......	....	.	......	....	3,186,710	Niagara L. & O. Pw. Co. ..		
								6,347,054	Erie Lt. Co.		
								28,880	Waldemere Park	9,504,884	....
2.	Butler Rys. Co.	.	......	....	.	......	....	646,196	West Penn Pw. Co.	646,196	258
3.	Chambersbg. & G. El. Ry. Co.	.	......	....	.	......	....	646,000	Pa. R. R. Co.		
								173,648	C. & S. R. Co.		
								42,630	Chambersbg. Mun. Plt.	429,722	....
4.	Chambersbg. & Ship. Ry Co.	.	......	....	.	......	....	16,200	Pa. R. R. Co.	16,200	....
5.	Ephrata & Lebanon Tr. Co.	.	......	....	.	......	....	1,200,700	Conestoga Tr. Co.	1,200,700	....
6.	Fairmont Park Tr. Co.	1	1,800	1,149,020	.	......	....	125,400	Woodside Realty Co.	1,023,620	1,150
7.	Frankford, Tacony & Holmsbg. St. R. Co.	.	......	....	.	......	....	1,887,800	Phila. Elec. Co.	1,887,800	582
8.	Harrisburg Rys. Co.	1	3,600	8,889,584	.	......	....	3,764,400	Harrisbg. L. & P. Co.	12,653,984	4,350
9.	Hershey Tr. Co.	3	5,420	22,124,181	1	Oil 900	5,975,668	2,015,839	Used by Ry.	24,084,010	....
10.	Homestead & Mifflin St. Ry Co. ..	.	......	....	.	......	....	587,730	Pittsbg. Ry. Co.	587,730	....
11.	Ind. Co. St. Ry. Co.	.	......	....	.	......	....	2,205,290	Luzerne Pw. Plt.	2,205,290	500
12.	Jefferson Tr. Co.	2	1,200	1,821,430	.	......	....	194,590	P. & R. Coal & I. Co.	1,967,450	911
								48,570	Harmony & M. Lane		
13.	Johnstown Tr. Co.	1	1,500	6,703,200	.	......	....	875,080	Penn P. S. Co.	7,578,280	2,020
14.	Lack. & Wyo. V. R. Co.	.	......	....	.	......	....	8,410,918	L. & Wyo. Pw. Co.	8,410,918	....
15.	Lanc. & York Furn. Ry. Co.	.	......	....	.	......	. ...	322,300	Ed. E. Co.	322,300	....
16.	M. C. & L. T. Co.	1	600	747,100	.	......	....	....	....	747,100	300
17.	Moutoursville Pass Ry. Co.	.	......	....	.	......	. ...	104,550	Montoursville El. Co.	104,550	....
18.	North Branch Tr. Co.	.	......	....	.	......	....	1,473,849	Pa. Pw. & Lt. Co.	1,473,849	553
19.	North Cambria Tr. Co.	.	......	....	.	......	....	627,820	Penn Central L. & P. Co. ..	627,820	266.4
20.	Olean & Bradford & Sal. Ry. Co...	.	......	....	.	G&O1,75	4,921,000	326,800	Front N. Y. Plant	2,500,000	1,500
		.	......	....		......	(Half used in Pa.)				
21.	Pa. & N. J. Ry. Co.	1	2,100	4,800,000	.	......	....	1,200,000	Bucks Co. El. Co.	3,600,000	1,200
22.	Phila. & Easton Tr. Co.	.	......	....	.	......	....	1,777,800	Clymer Pw. Co.	1,777,800	250
23.	Phila. Rys. Co.	.	......	....	.	......	....	940,500	Phila. El. Co.	940,500	250
24.	Phila. Rapid Tr. Co.	5	74,875	116,686,993	.	......	....	219,788,502	Phila. El. Co.		
								10,031,085	Phila. H. E. Co.	346,506,580	110,446

POWER USED BY ELECTRIC RAILWAYS OPERATING IN PENNSYLVANIA—Continued

Local Properties

Listed in Moody's Manual

No.	Name of Local Co.	Steam Plants No	Steam Plants Cap.	Steam Plants Kwh. Gen.	Water, Gas, Oil Plants No.	Water, Gas, Oil Plants Cap.	Water, Gas, Oil Plants Kwh. Gen.	Purchased Power Kwh.	Purchased Power From Whom	Total Power	System Peak
25.	Phila. & W. Chester Tr. Co.	1	4,300	9,182,870	.	......	....				
		1	800	64,380	.	......	....	....	....	9,247,250	2,520
26.	Phila & Western Ry. Co.	.	......	....	.	......	....	8,511,000	Count. G. & E. Co.		
								242,541	Norristown T. Co.	8,268,459	5,000
27.	Pittsburgh, Har. But. & N. C. St. Ry. Co.	.	......	....	.	......	....	12,402,747	Harmony E. Co.	12,402,747	2,724
28.	Pittsbg, Marrs & Butler St. R. Co.	.	......	....	.	......	....	3,800,000	Harmony E. Co.	3,800,000	834
29.	Schuylkill Ry. Co.	.	......	....	.	......	....	2,400,000	Pa. L. & P. Co.	2,400,000	1,162
								740,276	Abington E. Co.	4,010,150	2,900
30.	Scranton, Montrose & Bing. Ry.							143,893	Nickelson Lt. Co.		
	Co.	1	4,050	12,984,010	.	......	... .	1,511	Winola Lt. Co.		
								8,088,180	Binghampton Ry. Co.		
31.	Shamokin & Edgewood El. Ry. Co.	.	......	....	.	......	....	677,922	Pa. Pw. & L. Co.	677,922	550
32.	Shamokin & Mt. Carmel Ry. Co. .	.	......	....	.	......	....	1,531,539	Pa. Pw. & L. Co.	1,531,539	650
33.	Skippack & Perkiomen Tr. Co.	.	......	....	.	......	.. ..	325,037	Read. T. & L. Co.	325,037	250
34.	Slate Bet Tr. Co.	.	......	....	.	......	....	832,000	Pa. Ed. Co.	1,238,344	315
								406,344	Bangor El. Co.		
35.	Southern Cambria Ry. Co.	1	1,600	2,379,591	.	......	....	....	....	2,379,591	1,000
36.	Stroudsbg Tr. Co.	.	......	....	.	......	....	511,540	Pa. Pw. & L. Co.	511,540	180
37.	Titusville Tr. Co.	.	......	....	.	......	....	135,150	Titusville L. & P. Co.	135,150	35
38.	Trenton, Bristol & Phila. St. Ry. Co.	.	......	....	.	......	....	683,400	E. Pa. G. & E. Co.	683,400	200
39.	United Tr. & Ry. Co.	.	.....	....	.	......	. ...	538,000	DuBois El. Co.	538,000	400
40.	Valley Ry. Co.	.	......	....	.	......	....	3,815,143	United El. Co.	3,815,143	1,000
41.	Warren St. Ry. Co.	.	.....	....	1	G 1,600	5,000,000	....	....	5,000,000	....
42.	Warren & Jamestn. St. Ry. Co. ..	.	......	....	.	......	....	1,500,000	Warren St. Ry. Co.	1,500,000	300
43.	Waverly, Sayre & Athens St. Ry. Co.	.	......	....	.	......	....	638,040	Sayre El. Co.	638,040	400
44.	W. M. B. V. & F. C. St. Ry. Co. ..	.	......	....	.	......	. ...	480,000	W. Penn Pw. Co.	480,000	162
45.	West Chester St. Ry. Co.	.	......	....	.	......	....	1,382,514	Chester V. E. Co.	1,382,514	400

46.	West Chester, Kennett & Wil. Ry. Co.	.	......	....	.	......	....	350,000	Chester Co L. & P. Co.	350,000	60
47.	Wilkes-Barre Ry. Co.	2	6,100	19,168,600	.	......	....	4,600	Country Club	19,162,000	4,000
48.	W. B. & Hazelton Ry. Co.	1	2,000	4,658,500	.	......	....	2,995,200	Pa. Pw. & Lt. Co.	3,733,449	1,500
								3,588,800	Lehigh Tr. Co.		
								18,121	Anthracite Pw. Co.		
49.	Woodlawn & Southern St. Ry. Co.	.	......	....	.	......	....	313,330	Jeddo H. Coal Co.		
50.	York Rys. Co.	.	......	....	.	......	....	988,131	J. & L. Steel Co.	988,131	600
51.	Steubensville E. L. & B. W. Trac. Co.	.	......	....	.	......	....	7,068,828	Ed. Lt. & Pw. Co.	7,068,828	2,000
		.	......	No data	.	......	....				

TOTALS:	Capacity Kw.	Kwh. Generated or Purchased	Kwh. Sold
Prime Movers—Steam	109,945	211,359,459	....
Oil and Gas	4,250	13,896,668	....
Purchased Power	....	317,334,409	....
Power Sold to other users	....	....	16,776,219
	114,195	542,590,536	16,776,219

Total kwh. used for Ry. operation 522,064,517

POWER USED BY ELECTRIC RAILWAYS
Local Properties
Not Listed in Moody's Manual

	Name of Local Co.	Steam Generation Water, Gas or Oil				Purchased Power		Total Power	System Peak
		Cap.	Kwh. Gen.	Cap.	Kwh. Gen.	Kwh.	From Whom		
1.	Allen St. Ry Co.	......	....	......	....	172,580	Lehigh V. Tr. Co.	172,560	60
2.	Berwick & Nescopeck St. Ry. Co.	......	....	......	....	64,622	Pa. Pw. & Lt. Co.	64,622	50
3.	Bethlehem Tr. Co.	......	....	......	....	267,628	Lehigh V. Tr. Co.	267,628	......
4.	Blue Ridge Tr. Co.	......	....	......	....	69,230	Lehigh V. Tr. Co.	62,230	......
5.	Cambria Inc. Plane Co.	......	....	......	....	326,293	Cambria Steel Co.	236,293	......
6.	Carlisle Mt. Holly Ry. Co.	......	....	......	....	146,400	United Elec. Co.	146,400	125
7.	Corry & Columbus Tr. Co.	......	....	......	....	85,000	Gen. Elec. Co.	85,000	......
8.	Danville & Sunbury Tr. Co.	......	....	......	....	46,534	Pa. Pw. & Lt. Co.	46,534	59
9.	Duquesne Inc. Plane Co.	100	....	......	....	Incline	Plane Ry.	....	......
10.	E. Erie Com. Ry. Co.	......	....	......	....	371,720	Gen. Elec. Co.	371,720	......
11.	E. Liverpool Tr. Co.	......	....	......	....	1,056,560	Ohio Pw. Co.	1,056,560	175
12.	Fairchance & Smithfield Tr. Co.	......	....	......	....	63,960	West Penn Pw. Co.	63,960	52
13.	Hanover & McSherrystn. St. Ry.	......	....	......	....	370,674	Hanover Pw. Co.	370,674	150
14.	Highland Grove Trac. Co.	......	....	......	....	66,230	Pillsburg Ry. Co.	66,230	......
15.	Huntgdon, Lewistn. & J. V. Tr. Co.	......	....	......	....	197,900	Raystown W. P. Co.	197,900	100
16.	Irving Herminie Tr. Co.	......	....	......	....	345,165	West Penn Pw. Co.	345,165	147
17.	Jersey Shore & A. F. Ry. Co.	......	....	......	....	32,430	Pa. Pw. & Lt. Co.	32,430	......
18.	Johnstown & Somerset Ry. Co.	......	....	......	....	287,500	Penn P. S. Co.	287,500	166
19.	Lewisbg., Milton & Watsontn. Ry. Co.	......	....	......	....	332,400	Pa. Pw. & Lt. Co.	332,400	120
20.	Lykens Valley Ry. Co.	......	....	......	....	263,601	Lykens V. Lt., Ht. & Pw. Co.	263,601	70
21.	Mont. & Chester El. Ry. Co.	......	....	......	....	239,627	Phila. Sub. G. & E. Co.	239,627	250
22.	Monongahela Inc. Plane Co.	290	....	......	....	52¢ per r	ound Trip Met. Ed. Co.	....	......
23.	Mt. Penn Gravity R. R. Co.		Current p	aid for	at rate of	Incline	Plane Ry.	....	......
24.	New Castle & Lowell Ry. Co.	......	....	......	....	797,994	Pa.-Ohio P. & L. Co.	797,994	300
25.	Northampton Tr. Co.	......	....	......	....	1,867,245	Pa.-Edison Co.	1,867,245	462
26.	Northumberland Co. Ry. Co.	......	....	......	....	519,782	Pa. Pw. & Lt. Co.	519,782	277
27.	Patterson Hts. St. Ry. Co.	......	....	......	....	Record	Beaver V. Trac. Co.	....	......
28.	Phoenixville, V. F. & St. Ry. Co.	......	....	......	....	161,638	Phila. Sub. G. & E. Co.	161,638	250
29.	Pottstown Tr. Co.	......	....	......	....	791,074	Phila. & Sub. Co.	791,074	500
30.	St. Clair Inc. Plane Co.	......	....	......	....	148,836	Duquesne Lt. Co.	148,836	......

31.	Shenango V. Tr. Co.	......	....	......	....	1,663,520	Shenango V. E. L. Co.	1,663,520	690
32.	S. & S. Ry. Co.	500	780,000	......	....	....	....	780,000	405
33.	Susquehanna Tr. Co.	......	....	......	....	455,898	Lock Haven E. L. P. Co.	455,898	140
34.	T. B. & Butler St. Ry. Co.	......	....	......	....	340,170	Natrona L & P. Co.	340,170	250
35.	Westmoreland Co. Ry. Co.	......	....	......	....	251,690	West Penn Pw. Co.	251,690	83
36.	West Side El. St. Ry. Co.	......	....	......	....	710,843	West Penn Pw. Co.	710,843	310
37.	Whitehall St. Ry. Co.	......	....	......	....	380,512	Lehigh V. Tr. Co.	380,512	50
38.	East End Pass. Ry. Co.	NO RECORDS							
39.	Mt. Carmel & Locust Gap T. Co. ..	NO RECORDS							
40.	Sunbury, Lewisbg. & Milton Ry. Co.	NO RECORDS							
41.	Easton Transit Company	NO RECORDS							
42.	Scranton & Binghampton Tr. Co. ..	NO RECORDS							
43.	Valamount Trac. Co.	NO RECORDS							

TOTALS:	Capacity	Kwh. Generated or Purchased
Prime Movers—Steam	800	780,000
Purchased Power	...	12,894,876
Total	800	13,674,876
Total kwh. used for Ry. operation	13,674,876	

ELECTRIC RAILWAYS OPERATING IN PENNSYLVANIA
Properties Controlled by Holding Companies

	Name of Holding Company Name of Local Company	Counties in which system Operates by No.—See Index	Number of Twp.	Number of Cities	Number of Boro.	Number of Towns	Miles Right-of-Way occupied City Track	Miles Right-of-Way occupied High-ways	Miles Right-of-Way occupied Private	Remarks:
A.	Allentown & Read. Trac. Co.	....	....	....	....	....	4	36	30	....
B.	American El. Pw. Co.									
	Altoona & Logan V. E. Ry. Co. ...	7	6	1	5	....	26.3	6.45	23.29	....
	Peoples St. Ry. Co.	40	1	....	1	3	....	8.5	4	....
	Scranton Ry. Co.	58–35–40	3	3	16	....	56.02	33.50	14.28	....
	Southern Pa. Trac. Co.	23	7	Chester	16	....	26.94	21.01	6.26	....
D.	American W. W. & El. Co.									
	Allegheny V. St. Ry. Co.	2–65	7	....	17	....	(See West	Penn R	ys. Co.)	....
	Potomac Pub. Ser. Co.	....	....	....	....	....	....	.....	.....	....
	Hagerstown & Fred. Ry. Co.	28	....	....	....	1	....	.....	4.7	....
	Chambersbg., Greencastle & W. St. Ry. Co.	28	4	....	2	5	4	9.5	15.91	....
	West Penn Rys. Co.	2– 3–26–63–65	41	....	150	....	22.75	65.28	148.70	....
F.	Eastern Pa. Pw. & Rys. Co									
	Eastern Pa. Rys. Co.	13–54	11	Pottsville	15	....	15	5.1	44.97	....
G.	Electric Bond & Share Co.									
	Lehigh Valley Traction Co.	9–39–46–48	30	3	24	22	73.7	81.9	52.9	....
	Williamsport Pass. Ry. Co.	18–41	3	Williamsport	3	....	18.8	2	2	....
H.	Gen. Gas. & Electric Co.									
	Oley Valley Ry. Co. .... } Reading Tr. & Lt. Co. .... }	6–38–36–46–51	33	....	22	26	75.07	50.25	48.40	....
J.	Municipal Service Co.									
	Citizens Trac. Co.	61	4	2	2	....	13	2	17.28	....

K.	Pa.-Ohio Electric Co.									
	New Castle City Lines	37	4	New Castle	....	....	.91	.....	.....	....
	New Castle & Lowell Ry. Co.	37	2	New Castle	....	....	....	.....	10.01	....
	Shenango Valley Tr. Co.	43	2	Sharon	4	....	11.20	.....	2.4	....
L.	Penna. Electric Company									
	Center & Clearfield Ry. Co.	14–17	3	....	2	3	1.5	4	6.5	....
	DuBois Trac. Co.	17	1	DuBois	....	....	2.01	1.07	1.9	....
	Northwestern El. Ser. Co.	20–25	9	Erie Meadville	5	7	11.12	35.36	17.92	....
M.	Penn Central Pw. Co.									
	Lewistn. & Reedsville El. Ry. Co.	44	3	....	2	1	4	4.5	.7	....
Q.	United Gas & Electric Co.									
	Conestoga Trac. Co.	36	....	....	....	....	16.6	72	76.4	....
S.	United Railway Inv. Co.									
	Beaver V. Trac. Co.	4	....	....	6	6	48.5	.....	2	....
	Clairton St. Ry. Co.	2	....	Clairton	....	....	1.0093	.....	......	....
	Pittsburgh Railway Co.	2–63–65	30	4	63	....	243.6	8.5	83.9	....

TOTALS:

No. of counties in which operated 32
No. of cities in which operated 22
No. of boroughs in which operated 355
No. of towns in which operated 74

Miles right of way—City streets 676.05
Highways 446.92
Private Right of Way 614.42

ELECTRIC RAILWAYS OPERATING IN PENNSYLVANIA
Local Properties
Listed in Moody's Manual

	Name of Holding Company / Name of Local Company	Counties in which System Operates by No.—See Index	Number of				Miles Right-of-way Occupied			Remarks:
			Twp.	Cities	Boro.	Towns	City Track	High-ways	Private	
1.	Buffalo & Lake Erie Tr. Co.	25	3	Erie	2	....	45.29	14.10	22.43	....
2.	Butler Rys. Co.	10 Butler	....	....	....	....	5.65	.5	2.32	....
3.	Chambersbg. & Gettysbg. E. Ry. Co. ..	28	2	....	1	....	3	9.07	......	....
4.	Chambersburg & Shippensbg. Ry. Co...	28	1	....	3	....	1.5	.5	10.5	....
5.	Ephrata & Lebanon Trac. Co.	36–38	4	Lebanon	....	....	1.4	8	13.7	....
6.	Fairmount Park Tr. Co.	51	....	Philadelphia	....	....	....	.....	6.18	....
7.	Frankford Tacony Holmesbg. S. R. Co.	51	....	Philadelphia	....	....	18	.....	......	....
8.	Harrisbg. St. Ry. Co.	22	7	Harrisburg	6	8	35.71	5.14	13.5	....
9.	Hershey Tr. Co.	22–36–38	6	Lebanon	3	1	1.25	23.18	12.26	....
10.	Homestead & Mifflin St. Ry. Co.	2	1	....	2	....	.5	2.5	......	....
11.	Indiana Co. St. Ry. Co.	32	7	....	4	10	6	.....	30.25	....
12.	Jefferson Tr. Co.	33	3	....	3	4	3.5	2	26.5	....
13.	Johnstown Tr. Co.	11–56	4	Johnstown	6	...	21.63	.17	6.07	....
14.	Lack. Wyo. Ry. Co.	35–40	1	3	2	....	....	.....	23.40	....
15.	Lanc. & York Furnace St. Ry. Co. ..	36	3	....	....	3	....	.....	12.50	....
15a.	Lehigh Trac. Co.	13–40–54	4	Hazleton	4	7	5	1	14.63	....
16.	Mauch Chunk & Lehighton Tr. Co. ..	14	2	....	3	....	6.5	1	5	....
17.	Montoursville Pass. Ry. Co.	41	1	....	1	....	2	3.3	......	....
18.	North Branch Tr. Co.	19–47	5	....	5	5	2	3.3	7.7	....
19.	North Cambria Ry. Co.	11	....	....	3	....	4.5	.....	8.3	....
20.	Olean, Bradford Salamanca Ry. Co. ..	42–53	2	1	2	....	7	40	25	....
21.	Pa.-N. J. Ry. Co.	9	....	....	7	....	7	15	25	....
22.	Phila. & Easton Tr. Co.	9–48	....	Easton	2	....	2	.....	29	....
23.	Phila. Rys. Co.	51	....	Philadelphia	....	....	6.85	1.84	.18	....
24.	Phila. Rapid Transit Co.	9–23–46	14	Philadelphia	14	....	521.13	54.22	29.38	....
25.	Phila. & W. Chester Ry. Co.	15–23–46	8	....	7	....	....	21.44	13.26	....
26.	Phila. & Western Ry. Co.	15–23–46	....	....	2	....	....	.....	17.2	....
27.	Pittsbg., Har., But. & N. C. Ry. Co...	2–10 –4 –37	16	2	4	4	4	.....	65	....
28.	Pittsbg., Marrs & Butler Ry. Co. ...	2	7	Butler	3	....	....	.....	......	....
29.	Schuylkill Ry. Co.	54	7	....	9	....	9.02	13.51	14.88	....

30.	Scranton, Mont. & Binghptn. Ry. Co.	35-66-58	9	Scranton	8	1	1.3	7	37.4	....
31.	Shamokin & Edgewood Ry. Co.	49	1	....	1	2	3	3	5.86	....
32.	Shamokin & Mt. Carmel Tr. Co.	19-49-54	3	....	5	....	3	16	......	....
33.	Skippack & Perkiomen Tr. Co.	46	4	....	1	....	4	2.62	10	....
35.	Southern Cambria Ry. Co.	11	2	Johnstown	4	....	2.5	.....	22.5	....
34.	Slate Belt Tr. Co.	48	2	....	5	5	6	.....	10.4	....
34a.	Steubensville, E. L. & B. V. Tr. Co. ..									
36.	Stroudsburg Tr. Co.	45-48	2	....	4	1	6	4	3	....
37.	Titusville Tr. Co.	20-61	3	Titusville	2	....	....	2.25	10.10	....
38.	Trenton, Bristol, & Phila. St. Ry. Co.	9	3	....	3	5	....	13.3	3.5	....
39.	United Tr. St. Ry. Co.	17-33	2	DuBois	2	2	1.4	2.11	11.19	....
40.	Valley Rys. Co.	21-50-22	5	Harrisburg	9	3	.12	34.60	11.76	....
41.	Warren St. Ry. Co.	62	4	....	2	....	6	7	7	....
42.	Warren & Jamestn. St. Ry. Co.	62	1	....	1	....	....	4	10	....
43.	Waverly, Sayre & Athens Tr. Co.	8	1	....	2	....	7.91	.....	......	....
44.	Web. Monessen, B. V. & F. C. St. Ry. Co.	26-65	2	Monessen	2	3	3.35	1.32	2.47	....
45.	W. Chester St. Ry. Co.	15	7	Coatesville	2	....	5.12	4.47	13.78	....
46.	W. Chester, Kennet & Wil. E. R. Co...	15	2	....	3	1	1.2	1.1	5.2	....
47.	Wilkes-Barre Ry. Co.	40	6	2	1	2	....	.....	29.86	....
48.	Wilkes Barre- Hazleton Ry. Co.	40	7	2	7	12	38.35	16	28.75	....
49.	Woodland & Southern St. Ry. Co. ...	4	....	....	2	....	3	.....	.7	....
50.	York Railways Co.	67	14	York	13	5	11.94	28.70	33.36	....

TOTALS:

No. of Counties in which operated	42
No. of Cities in which operated	25
No. of Boroughs in which operated	177
No. of Towns in which operated	84
Miles of right of way—City Streets	820.42
Highways	377.24
Private Right of way ..	695.97

ELECTRIC RAILWAYS OPERATING IN PENNSYLVANIA
Local Properties
Not Listed in Moody's Manual

	Name of Local Company	Counties in which System Operates by No. See Index	Number of				Miles Right-of-way Occupied			Remarks:
			Twp.	Cities	Boro.	Towns	City Track	High-ways	Private	
1.	Allen St. Ry. Co.	48	1	....	2	....	1.72	1.67	1.78	....
2.	Berwick & Nescopeck St. Ry. Co.	11-40	....	....	2	....	1.66	....	....	....
3.	Bethlehem Transit Co.	39-48	2	Bethlehem	....	5	1	5.50	.50	....
4.	Blue Ridge Trac. Co.	48	1	....	1	....	5	4.5	1.5	....
5.	Cambria Incline Plane Co.	11	....	Johnstown	1	....	....	....	.25	....
6.	Carlisle & Mt. Holly Ry. Co.	21	1	....	2	....	1.75	....	4.50	....
7.	Corry & Columbus Trac. Co.	25-62	1	Corry	1	....	....	4	....	....
8.	Danville & Sunbury Transit Co.	47-49	1	....	2	....	2	1	....	....
8a.	Duquesne & Dravosburg St. Ry. Co.	....	....	....	....	....	....	....	....	....
9.	Duquesne Inc. Plane Co.	2	....	Incline Plane	....	....	....	....	....	....
38.	East End Pass. Ry. Co.	....	....	....	....	....	....	....	....	....
10.	East Erie Comm. Ry.	25	1	....	2	....	....	8.22	....	....
11.	E. Liverpool Trac. & Lt. Co.	4	3	....	2	1	2.1	2.12	6.9	....
41.	Easton Transit Co.	....	....	....	....	....	....	....	....	....
12.	Fairchance & Smithfield Tr. Co.	26	1	....	1	2	.5	....	2.25	....
13.	Han. & McSherrystn. St. Ry. Co.	1-67	3	....	3	....	5	1	3	....
14.	Highland Grove Trac. Co.	....	1	3	....	....	3	....	1	....
15.	Hunt., Lewistn. & Jun. Val. Tr. Co.	31	....	1	....	....	1.625	....	....	....
16.	Irving-Herminie Trac. Co.	65	2	....	1	3	.125	600 ft.	5.25	....
17.	Jersey Shore & Antes Fort R. R. Co.	41	1	....	1	1	.2	.05	2.5	....
18.	Johnstown & Somerset Ry. Co.	56	1	....	....	2	....	10	....	....
19.	Lewisbg., Milton, & Watson P. R. Co.	49-60	6	....	4	1	3	7.5	11	....
20.	Lykens Valley Ry. Co.	22-54	3	....	3	4	3	7.1	....	....
22.	Monongahela Inc. Plane Co.	63	....	Monongahela	....	....	Incline	Plane	....	....
21.	Montgomery & Chester Ry. Co.	15	3	....	2	....	3.5	....	....	....
21a.	Mt. Carmel & Locust Gap. T. Co.	....	....	....	....	....	....	....	....	....
23.	Mt. Penn Gravity R. Co.	6	1	Reading	....	....	Incline	Plane	....	....
24.	New Castle & Lowell Ry. Co.	37	2	New Castle	....	....	....	....	10.01	....
25.	Northampton Transit Co.	48	3	Easton	4	....	3.2	4.5	14.5	....
26.	Northumberland Co. Ry. Co.	49	1	Sunbury	1	1	4.875	.5	.5	....

27.	Patterson Hts. St. Ry. Co.	4	....	....	....	....	Incline	Plane	......	....
28.	Phoenixville, Valley F. & Straf. E. R Co.	15	1	....	1	....	1.5	.25	3.75	....
29.	Pottstown Transit Co.	15–46	4	....	6	....	3	3.5	3.5	....
30.	St. Clair Inc. Plane Co.	2	....	Pittsburgh	....	....	Incline	Plane	......	....
31.	Shenango Val. Trac. Co.	43	2	Sharon	4	....	11.20	.....	2.40	....
32.	Sunbury & Selinsgrove Ry. Co.	....	2	Sunbury	1	4	2	.....	4.2	....
42.	Scranton & Binghamton T. Co.	....	....	....	....	....	....	.....	......	....
40.	Sunbury, Lewisburg. & Milton Ry. Co.	....	....	....	....	....	....	.....	......	....
33.	Susquehanna Trac. Co.	18	2	Lock Haven	2	....	3.5	1.3	1	....
40.	Tarn.-Brackenridge-Butler St. Ry Co...	2	1	....	2	....	1.8	.....	1.5	....
43.	Vallamont Trac. Co.	....	....	....	....	....	....	.....	......	....
35.	Westmoreland Co. Ry. Co.	65	1	....	2	2	1	4	2	....
36.	West Side El. St. Ry. Co.	33–65	2	Monessen	4	1	1.97	.....	9.424	....
37.	Whitehall St. Ry. Co.	....	....	....	....	....	....	.....	......	....

TOTALS:

No. Counties in which operated 28
No. Cities in which operated 16
No. Boroughs in which operated 57
No. Towns in which operated 27
Miles right of way—City streets 67.41
Highways 66.71
Private right of way 93.31

STEAM RAILROADS—OPERATING IN PENNSYLVANIA

	Operating Company—Name	Miles Private Right-of-Way	Car Miles Pass. Ser.	Ton Miles Freight	Switching Miles	Ton Coal Used (2000 lbs.) Pass. Scr.	Freight	Switching
1.	Aliquippa & Southern R. R. Co.	....	....	....	464,634	......	....	18,125
2.	Alleg. & Southside R. R. Co.	1.33	....	....	46,482	......	....	1,960
3.	Altoona Northern R. R. Co.	....	....	....	....	......	....	......
4.	Baltimore & Ohio R. R.	674.5	15,481,476	5,018,467,052	1,864,560	160,944	737,013	147,948
5.	Bare Rock R. R. Co.	2.5	....	6,250	....	......	100	......
6.	Beaver Valley R. R. Co.	....	....	3,250	....	......	200	......
7.	Bessemer & Lake Erie R. R. Co.	202.19	1,866,088	2,881,816,000	462,163	25,563	247,169	19,280
8.	Bellefonte Central R. R. Co.	....	11,680	337,489	....	......	3,500	......
9.	Bloomsbg. Sullivan R. R. Co.	28.81	106,717	904,175	....	1,342	671	......
10.	Brownstone & Middletn. R. R. Co.	....	497	2,257	8,252	......	421	......
11.	Buffalo & Sus. R. R. Corp.	222.84	265,628	218,111,000	75,923	4,342	42,900	4,000
12.	Buffalo Roch. & Pttsbg. R. R. Co.	301.81	2,685,964	1,842,260,025	835,745	44,423	242,372	48,214
13.	Cambria & Indiana R. R. Co.	....	22,486	1,340,748	44,546	......	12,494	......
14.	Central R. R. of N. J.	197.14	2,630,562	1,889,392,787	1,042,766	38,911	218,401	79,578
15.	Cherrytree & Dixonville R. R. Co.	38.37	....	....	....	......	....	......
16.	Chestnut Ridge R. R. Co.	....	25,631	1,557,187	2,190	2,681	1,058	......
17.	Cornwall R. R. Co.	12.67	75,393	6,759,357	66,216	1,493	1,975	4,804
18.	Coudersport & Port Alleg. R. R. Co.	....	46,028	1,461,252	950	987	1,876	100
19.	Delaware & Hudson R. R. Co.	....	1,220,316	1,350,458,730	628,964	21,427	232,907	31,316
20.	Delaware, Lack. & West. R. R. Co.	252.42	16,137,138	3,705,957,099	1,799,944	95,700	407,842	53,151
21.	Delaware Valley R. R. Co.	12.4	27,005	....	....	......	749	......
22.	Dents Run R. R. Co.	....	....	495,600	3,163	......	378	......
23.	Donora Southern R. R. Co.	32.97	....	....	1,820,004	......	....	12,332
24.	E. Broadtop R. & Coal Co.	73.24	157,277	8,928,771	25,321	1,295	3,670	822
25.	Erie R. R. Co.	518.40	1,826,550	608,976,000	147,207	53,300	386,225	58,253
26.	Etna & Montrose R. R. Co.	1.03	....	....	60,840	......	....	1,832
27.	Hickory Valley R. Co.	5.52	....	293,007	8,135	......	297	250
28.	Hunt. & Broadtop Mt. R. & C. Co.	74.46	210,555	60,620,247	87,279	5,848	12,373	1,997
29.	Indiana Creek Valley R. R. Co.	23	29.532	13,497,589	....	1,920	3,494	......
30.	Ironton R. R. Co.	13	....	7,025,194	45,980	......	5,217	......
31.	Johnstown & Stony Cr. R. Co.	1.82	....	....	....	......	....	1,780
32.	Kane & Elk. R. R. Co.	7.9	....	233,962	2,851	......	450	300
33.	Kishacoquillas Val. R. R. Co.	9.5	18,780	13,974	....	......	500	......
34.	Lake Erie Frank. & Clar. R. R. Co.	24.45	123,010	5,922,456	....	2,737	7,466	......

35.	Lehigh & New Eng. R. R. Co.	178.53	47,399	341,339,540	534,700	1,173	51,996	23,225
36.	Lehigh Valley R. R. Co.	614.78	5,170,455	2,680,952,118	2,101,842	144,424	507,145	108,672
37a.	Ligonier Valley R. R. Co.	16	64,802	13,714,863	......	914	3,923	......
37b.	McKeesport & Connecting R. R. Co.	6.05	......	......	......	......	......	18,910
38.	Maryland & Pa. R. Co.	37.40	227,970	8,145,754	20,316	3,369	2,672	1,266
39.	Mercer Valley R. Co.	3.99	......	......	72,690	......	......	2,145
40.	Monongahela Con. R. Co.	......	......	......	1,015,884	......	......	39,958
41.	Monongahela R. R. Co.	70.74	358,941	404,647,000	225,417	6,447	30,433	54,246
42.	Montour R. Co.	54	100,166	169,339,000	27,887	1,506	17,233	2,087
43.	Mt. Jewett Kinzua, & Rittervl. R. Co.	25	10,832	191,724	3,000	500	400	100
44.	Mt. Penn Gravity R. R. Co.	8	8	......	......	......	......	......
45.	Northampton & Bath R. Co.	12.39	......	12,603,442	14,751	......	5,663	2,081
46.	New York Central R. Co.	642.47	8,603,007	5,661,370,284	669,804	65,321	377,351	47,681
47.	N. Y. C. & St. L. R. Co.	43.98	618,177	669,916,820	571,738	2,526	45,012	1,969
48.	N. Y. Ont. & Western R. R. Co.	69.83	142,916	230,919,809	133,587	2,352	31,121	6,603
49.	N. Y. & Pennsylvania R. Co.	29	......	774,022	......	......	1,334	......
50.	N. Y. Sus. & West. Ry. Co.	84.88	184,985	109,200,000	32,633	2,687	15,761	2,303
51.	Pencoyd & Phila. R. Co.	1.32	......	......	74,235	......	......	3,353
52.	Pennsylvania Railroad Co.	4,363.07	156,483,236	47,239,976,000	17,724,028	817,644	1,750,342	545 859
53.	Penn., West. & Ohio R. Con. R. R. Co.	75.75	......	......	......	......	......	......
54.	Peoples R. R. Co.	4.4	......	......	......	......	......	......
55.	Philadelphia-Bethlehem & N. E. Ry. Co.	72.52	......	......	471,798	......	......	23,490
56.	Pittsburgh & Alleg. & McKees Rocks R. Co.	......	......	......	......	......	......	3,485
57.	Pittsburgh & Lake Erie R. Co.	189.53	6,529,904	3,080,627,220	1,843,147	77,610	138,722	152,978
58.	Pittsburgh & Ohio V. Ry. Co.	2.04	......	......	15,636	......	......	846
59.	Pittsburgh & Sus. R. Co.	17.89	103	1,634,889	......	......	1,621	......
60.	Pittsburgh & Shawmut R. Co.	102.96	167,898	126,334,000	......	2,861	27,892	......
61.	Pittsburgh & W. Va. R. R. Co.	62.63	255,306	11,903,500	64,844	2,388	17,869	6,005
62.	Pittsburgh., Chart, & Youghiogheny R. Co.	19.66	......	8,585,515	66,400	......	2,496	3,048
63.	Pittsburgh, Shawmut & Northern R. Co.	112.67	202,680	108,776,240	24,940	3,642	21,579	1,817
64.	Pittsburgh, Lisbon & West. R. C.	10.35	17,442	1,857,743	3,711	538	1,284	409
65.	Potato Creek R. R. Co.	8.59	2,665	41,621	5,516	92	2,771	417
66.	Quakertown & Beth. R. R. Co.	15	......	6,233	......	......	......	160
67.	Reading Company	......	26,538,873	9,476,843,081	5,242,681	412,474	1,147,219	322,353
68.	Red Stone Central R. R. Co.	2.39	......	......	......	......	......	......
69.	Reynoldsville & Falls Cr. R. R. Co.	16.58	......	2,091,125	......	......	988	......
70.	Rural Valley R. R. Co.	18.21	10,310	2,465,389	......	......	1,000	3,000
71.	Scootac Ry. Co.	6.75	......	2,035	(Train Miles)	......	207	......
72.	Scottdale Connecting Ry. Co.	2.5	......	......	9,528	......	......	1,214

STEAM RAILROADS—OPERATING IN PENNSYLVANIA—Continued

	Operating Company—Name	Miles Private Right-of-Way	Car Miles Pass. Ser.	Ton Miles Freight	Switching Miles	Ton Coal Used (2000 lbs.)		
						Pass. Ser.	Freight	Switching
73.	Sharpsville R. R. Co.	17.75	21,148	398,282	43,350	....	1,336	1,606
74.	Southshore R. R. Co.	2	....	....	3,836	....	150	....
75.	Steelton & Highspire R. R. Co.	41.90	....	....	275,202	....	14,841	....
76.	Stewartstown R. R. Co.	16	28,800	16,722	(Train Miles)	....	1,490	....
77.	Strasburg R. R. Co.	4.5	....	....	....	....	250	....
78.	Sus. River & West. R. R. Co.	33.71	91,747	433,778	....	....	2.043	....
79.	Tionesta V. R. R. Co.	44.98	75,120	5,129,536	18,460	624	6,274	624
80.	Tuscarora V. R. R. Co.	27	70,340	338,543	3,990	....	1,400	....
81.	Sus. & N. Y. R. Co.	67.98	119,434	19,884,873	9,239	2,360	9,627	242
82.	Union R. Co.	45.77	....	....	4,102,978	....	....	297,241
83.	Unity Rys. Co.	....	4,416	1,989,587	5,952	150	566	514
84.	Upper Merion & Plym. R. R. Co.	4.94	....	239,266	255,513	....	646	8,114
85.	Ursina & North Fork Ry. Co.	5.75	....	12,699	....	....	557	....
86.	Valley R. R. Co.	10.41	....	116,226	....	....	590	....
87.	Washington Run R. R. Co.	....	10,752	1,285,645	6,260	....	1,080	....
88.	West. Allegheny R. R. Co.	....	101,080	27,068,091	35,556	2,164	10,747	6,408
89.	West. Inter Works R. R. Co.	5	....	1,009,215	5,063	....	157	313
90.	West. Md. R. R. C.	198.66	946,344	1,030,005,005	54,336	16,937	145,645	3,719
91.	Wilkes-Barre Con. Ry. Co.	....	....	....	....	....	....	....
92.	Williamsport & N. Branch R. Co.	46	47,049	545,084	3,842	1,532	2,513	141
93.	Winfield R. R. Co.	....	194,529	399,589	15,406	....	948	1,000

TOTALS:

			Coal Used (short tons)
Private Right of Way	10,279.47	Miles	....
Passenger Service	250,213,147	Car Miles	2,035,148
Freight Service	49,086,991,677	Ton Miles	6,940,567
Switching Service	35,353,605	Switching Miles	2,185,644
		Total Coal	11,161,359 short tons

RECAPITULATION OF SUMMARIES
Electric Power Utilities in Pennsylvania
Jan. 1, 1923

Total Capacity of Prime Mover Plants (Including Standby Capacities)				1,448,875 kw.
Total power generated by Steam prime movers			3,725,396,601 kwh.	
Total power generated by Hydro Electric Prime movers			483,232,506 kwh.	
Total power generated by Gas or Oil prime movers			26,335,828 kwh.	
Total Power Generated by Prime Movers				4,244,552,734 kwh.
	Steam	Hydro	Gas or Oil	
Capacity of Modern Efficient Plants Class "A"	855,230	98,500		953,730
Capacity of Medium Efficient Plants Class "B"	355,270	17,494		372,764
Capacity of Low Efficient Plants Class "C"	103,092		10,891	113,983
	1,313,592	115,994	10,891	1,440,477 kw.
Kwh. Generated by Class "A" plants	2,756,373,722	441,318,595		3,197,642,317 kwh.
Kwh. Generated by Class "B" plants	787,396,601	41,913,911		829,310,512
Kwh. Generated by Class "C" plants	181,971,675		26,335,837	208,307,512
	3,725,691,998	483,232,506	26,335,837	4,235,260,341
	Class "A"	Class "B"	Class "C"	Total
Capacities controlled by Holding Companies				
Steam	855,230	322,675	65,827	1,243,732 kw.
Hydro Electric	98,500	9,095		107,595
Gas or Oil			3,682	3,682
	953,730	331,770	69,509	1,354,009
Capacities Operated by Local Companies				
Steam		32,595	37,265	69,860 kw.
Hydro Electric		8,399		8,399
Gas or Oil			7,209	7,209
		40,994	44,474	85,468
Kwh. Generated by Controlled Companies				
Steam	2,756,323,722	724,561,203	117,184,311	3,597,978,236 kwh.
Hydro Electric	441,318,595	19,567,827		460,886,422
Gas or Oil			4,786,692	4,786,692
	3,197,642,317	744,128,030	121,971,003	4,063,651,350

RECAPITULATION OF SUMMARIES
Electric Power Utilities in Pennsylvania
Jan. 1, 1923

Kwh. Generated by Local Companies	Class "A"	Class "B"	Class "C"	Total
Steam		62,835,397	64,787,364	127,622,761 kwh.
Hydro Electric		12,346,134		12,346,134
Gas or Oil			21,549,145	21,549,145
		75,181,531	86,336,509	161,518,040

Coal Consumed	
Class "A" plants	2,899,784 short tons
Class "B" plants	1,231,754 short tons
Class "C" plants	447,364 short tons
Total	4,578,902 short tons

Coal Consumed by Companies	Class "A" Plants	Class "B" Plants	Class "C" Plants	Total
Holding Companies	2,899,680	1,126,215	260,225	4,286,125
Local Companies		104,308	183,921	188,229
	2,899,680	1,230,523	444,146	4,574,349

POWER PURCHASED

	Kwh. Purchased
Holding Companies	76,631,703
Local Companies	409,730,982
	486,362,685

POWER SOLD TO OTHER UTILITIES

	Power Sold to Utilities	Power Sold to St. Rys.	Total Sold
Holding Co's.	573,644,392	468,600,315	1,042,244,707
Local Co's.	27,879,692	32,678,357	60,558,049
	601,524,084	501,278,672	1,102,802,756

FINAL SUMMARIES

Total Power Produced by Steam Prime Movers		3,725,396,601
Total Power Produced by Hydro Prime Movers		483,232,506
Total Power Produced by Int. Comb. Eng. Prime Movers		26,335,828
Total Power Produced by Prime Movers within the State		4,244,552,734
Power Rec'd from Beyond the State's borders	342,047,831	
Power Deliv'd Beyond the State's Borders	284,547,200	
Excess Power Delivered over Received		57,500,631
Total Power Delivered to and Generated within the State		4,302,053,365
Total Power Sold to Consumers		3,771,151,809
Unaccounted for and losses (12%)		530,901,556

Coal Consumption—Average for all Steam plants—2.5 lbs. per kwh.

HOLDING COMPANIES

	Minimum (lbs.)	Maximum (lbs.)
Class "A" Steam Plants Averaged 2.3 lbs. per kwh. with	1.81 and	3.98
Class "B" Steam Plants Averaged 3.6 lbs. per kwh. with	1.94 and	8.55
Class "C" Steam Plants Averaged 4.45 lbs. per kwh. with	2.8 and	9.3

LOCAL COMPANIES

Class "B" Steam Plants Averaged 3.34 lbs. per kwh. with	2.9 and	16.
Class "C" Steam Plants Averaged 5.66 lbs. per kwh. with	3. and	22.2

Appendix B

I. RURAL ELECTRIFICATION STUDIES

Made in Cooperation with Pennsylvania Department of Agriculture

By R. U. Blasingame

Professor, Farm Machinery—Pennsylvania State College

Purpose

To determine the influence of Electricity upon the social and economic phases of Pennsylvania Agriculture.

What Has Been Done

A close study has been made of the Levi H. Brubaker farm, R. F. D. No. 8, Lancaster, Pa., which is well supplied with electrical equipment both in the house and in the barnyard.

a. Current is supplied from the Edison Electric Company, Lancaster, Penn'a.

b. There are two lines from the transformer to serve the farm.

1. Single phase for lights.
2. Three phase for power.

The monthly current consumption as metered for the period from February 1, 1923, to November 1, 1924, follows:

	Kwh. light	Kwh. power
February	46	56
March	134	19
April	61	86
May	20	96
June	15	66
July	17	172
August	12	496
September	15	175
October	20	209
November	28	119
December	29	191

	Kwh. light	Kwh. power
January	31	180
February	37	272
March	25	220
April	25	143
May	22	104

	Kwh. light	Kwh. power
June	21	106
July	26	141
August	34	506
September	28	135
October	50	178
November	44	260

FIG. 1. ELECTRIC IRONING MACHINE

Mrs. Levi H. Brubaker does her ironing with minimum of time and labor. She says, "Ironing is not the job it used to be."

c. The farm contains 133 acres. It is divided approximately into two equal sections. Each of these sections is divided into three fields averaging about 20 acres each. Each half of the farm is conducted upon a three year rotation, as follows:

1. Potatoes, wheat and alfalfa.
2. Tobacco, wheat and corn.

d. There are meters for each of the two lines entering the farm. However, these do not indicate the current consumption for individual pieces of equipment. To secure these figures, house type watt hour meters were installed on August 8, 1924, for the following equipment:

1. Potato grader, driven by one-half H. P. electric motor made by Boggs Mfg. Co.
2. Westinghouse electric range S#266732, largest house type, 2 ovens.
3. Simplex electric ironing machine, 46", 3600 watt, 220 volt operated by a 1/6 H. P. motor.
4. Washing machine.
5. Water pump in basement for general household purposes (soft water) driven by 1/6 H. P. motor.
6. Water pump in basement for drinking, lawn and garden sprinkling, auto washing, etc., driven by 1/6 H. P. motor.
7. Water pump outside to supply hogs in pasture during summer, driven by 1/2 H. P. motor.

The readings taken on these meters October 1, November 1, and December 1, were as follows; starting at zero readings:

Individual Meter Readings October, November, December

Name of Equipment	Readings Kwh. Oct.	Nov.	Dec.
Electric Range	112	206	352.0
Washing Machine	4	10	17.0
Potato Grader	1	3	3.5
Simplex Ironer	16	42	63.0
Goulds Pump	2	6	10.0
1/2 H. P. Pump (basement)	3	9	17.0
1/6 H. P. Pump (basement)	4	10	15.0

The range, the three pumps, and the Simplex ironer are on the three phase power line while the washing machine and potato grader are on the light or single phase line.

e. Without the use of water meters it was not possible to measure the amount of water pumped by the various water systems.

In case of the potato grader, during the month of September 700 bushels of potatoes were graded requiring only one kwh. while in October 1300 bushels were graded consuming two kwh.

From October 20th to November 7th, Mr. Brubaker filled two silos. His equipment for this work consisted of a Papec silage cutter and a 30 H. P. 220 volt, 60 cycle motor. Three teams and three men were used for delivering the corn to the silo. The time required to run three loads through the cutter averaged 20 minutes or 6.6 minutes per load or about two tons. The chart shows that it required about an hour for three men to bring in three loads. Six 20 minute actual running periods each day were necessary.

The chart shows that it required about 8 H. P. to operate the silage cutter empty. The blower no doubt consumed the bulk of the energy. About 30 H. P. were required to operate the outfit when cutting silage. This varies slightly above and below 30 H. P. as it is impossible to feed any silage cutter uniformly.

One very interesting thing was discovered; namely—that the energy consumption for filling the 26 foot silo was practically the same as for the 42 foot. This checks with the results obtained by F. W. Duffee, Wisconsin University, in some tests on silage cutters, reported in Agricultural Engineering, January, 1924.

The other demands for energy on the power line are well distributed through the day, not being excessive at any time other than for the silage cutting which is seasonal and can be expected at this time of the year.

FIG. 2. 30 H. P. ELECTRIC MOTOR FOR SILO FILLING

Mr. Levi H. Brubaker, Lancaster, Pa., R. F. D. 8, uses a 30 H. P. Motor for threshing grain, shredding fodder, filling silos and grinding feed. He says he would not farm if he had to be without electricity. It is essential.

YEARLY LABOR SCHEDULE ON BRUBAKER FARM

II. a. The division of the Brubaker farm into two equal parts and the crop rotation which has been mentioned above, is significant. It has direct bearing upon the labor schedule workout and upon the use of the electrically driven apparatus, both in the house and barnyard.

The farm is located near Lancaster where many factories offer employment at lucrative compensation, both for men and women. The change in demand for labor and in wage scale since the days when labor was cheap and plentiful makes it necessary to re-adjust the farm operation to fit these conditions. Thus the reason for this rather unusual system of rotation. It is difficult to go on the open market and secure farm help in large numbers and at reasonable prices to take care of heavy demands in rush seasons.

Rush seasons have therefore been eliminated to a great extent, and electrical equipment has been brought into play to straighten out the labor curve.

b. All businesses including that of farming, place a premium upon good management and efficient operation, so let us follow Mr. Brubaker's well planned schedule. He employs three men throughout the year and for three years has not hired any extra help. As early as the weather and soil conditions will permit in the spring, the potato ground, usually plowed in the fall, is prepared and planted to early potatoes. The corn ground is then plowed. The planting of late potatoes follows and the corn ground prepared for planting corn by about May 10 to 20th. Cultivating corn and potatoes, spraying potatoes and preparing the tobacco ground keep the men busy until tobacco planting early in June and the first cutting of alfalfa is coming on. Between times when alfalfa is being harvested, cultivation of crops and potato spraying goes on, potatoes being sprayed about every ten days. Next follows wheat harvest, all the wheat being threshed from the field, with the 30 H. P. electric motor. Threshing wheat from the field saves the labor of hauling it in and out of the barn and also reduces the loss of grain from the ravages of the Angoumois grain moth. (To control this moth the Agricultural Department advises: "Thresh wheat early.") The harvest takes up the latter part of July by which time early potatoes can be dug and sent to the market. All the potatoes are graded by the use of an electrically driven machine.

Then follow tobacco cutting, silo filling, and digging late potatoes during September and early October. The potato and tobacco ground is disked and sown to wheat. The late potatoes are now moved to market and corn husking comes into full swing. Usually fall weather allows the potato ground to be plowed before winter. As the ground freezes up the men turn their attention to the large tobacco sheds and "stripping" rooms where the tobacco is prepared for market.

When the potatoes are all graded, the grader is moved from the lower part of the barn, where steers are fed for the winter. The time required to feed the steers is only slight and fits in well with the winter program, silage being the principal feed for the steers.

Glancing over this schedule one sees how man labor may profitably be employed throughout the year and how careful planning brings profits while constantly improving the condition of the farm.

How Electricity Does Its Part

III. For a good many years Mr. Brubaker employed help in the house. This was found to be unreliable. He then turned his attention to a program of electrical equipment which would eliminate the necessity of hired help and accomplish the chores in a minimum amount of time.

"An electric range," says Mr. Brubaker, "does not require kindling, coal, or ashes to be removed. This latter is work for a man and man labor costs money. The electric range is clean, safe and efficient, and requires no attention." The same thing is true of the water systems, vacuum sweeper, the washing machine, ironer, and other electrical apparatus employed in his home. "It would be foolish," says Mr. Brubaker, "to work out an

efficient farm plan to have it broken into each day with small jobs about the house which can be done by electricity. Electricity is safe, sanitary and convenient. No gasoline engine radiators to freeze up, no difficulty in starting on cold mornings. Any of my farm help can start the motor and go off about other work. There is no storage of inflammable fuel."

He further says, "The home is deserving of everything which makes for ease, happiness and enjoyment. Electricity adds many of these. When we

FIG. 3. WELL ARRANGED KITCHEN, ELECTRIC RANGE, AND WATER SUPPLY

Mrs. Levi H. Brubaker, Lancaster, Pa., R. F. D. 8. These people have been successful in Agriculture. They find electricity a great help in the home and about the farm. Water under pressure (both soft and hard) from electrically driven pumps. Mrs. Brubaker finds that she is quite independent of hired help with the use of electric equipment in her home. She does not have to call upon the men to leave their field work to help out.

want ice cream I have a small motor to turn the freezer. The farmer gets sufficient exercise without this work. The same motor does the churning, grinds the knives and sharpens the farm tools."

ELECTRIC MOTOR DRIVE FOR FARM MACHINERY AT THE PENNSYLVANIA STATE COLLEGE

This report covers two projects of a series, the object of which is to study the application of electric motor drive to farm machinery. To date tests have been made on ensilage cutters and milking machines.

MOTOR DRIVE FOR ENSILAGE CUTTING

Equipment and Power Supply: The ensilage cutter used in this project was an International Harvester Company machine. It was driven by a thirty horse power, three phase, two hundred twenty volt squirrel cage induction motor, eleven hundred fifty revolutions per minute rated speed at full load.

The motor with its starting compensation was mounted on a simple frame built directly on the bolsters of a farm wagon. The frame consisted

FIG. 4. CUTTING SILAGE AT THE PENNSYLVANIA STATE COLLEGE, 30 H. P. G. E. MOTOR

Mr. C. L. Goodling, Farm Superintendent at The Pennsylvania State College, State College, Pa., said, "I never had so little trouble in filling the four silos as this year. Formerly, I used a steam engine. The even flow of power from the electric motor is easy on the machinery and secures best results."

of two sills, 4 x 5 inches laid edgewise on the bolsters. Cross pieces of two-inch material were then used to hold the sills in place, and to form a base for the motor. The compensator or starter for the motor was mounted on upright pieces fastened to the frame and securely braced.

Power for the motor was taken from the campus service lines at 2200 volts, three phase, and stepped down to 220 volts three phase by means of three 10 kva. transformers. These transformers were also mounted on skids so that they could be moved from place to place if necessary.

Metering: The energy consumed by the motor was measured by a watthour meter and transformers connected for a 20 to 1 ratio. The in-

stantaneous power demand was obtained by means of a Bristol Polyphase Recording Wattmeter. No attempt was made to obtain data for power factor determination because the rapidly fluctuating load made it impossible to obtain reliable data for power factor calculation.

Careful records were kept of the help and farm equipment required to keep this outfit working.

ENSILAGE CUTTING DATA

Date	Teams Hauling	Binders	Men Loading	Men in Silo	Tons	Meter Reading	Remarks
						0	Used 60 ft. belt
9/11	4	1	6	3	31.5	2.5	at start.
							Changed to 40 ft. belt
9/12	4	2-1*	6	3	62.5	6.8	with better results.
				3		No record	
9/15	4	2	6	3	82.7	One meter element out.	
9/16	4	2	6	3	53.8	15.4	First silo full
9/16	4	2	6	3	6.9		Second silo
9/17	4-5*	1	6	3	77.1		
9/18	5	2	6	3	78.0		
9/19	5	2	6	3	77.1	32.2	Second silo full
9/23	5	2	6-5*	3	68.5		
9/24	5	2	5	3	64.8	41.6	Third silo full
9/26	5	2	5-6*	2	68.9		
9/27	5	2	6	6	28.4		Worked half day
10/ 1	5	2	6	3	46.1	52.1	Fourth silo filled

*When two numbers appear in the table above, the first of the two refers to the time between morning and noon while the second is for the time between noon and evening.

The total number of tons of silage cut was 746.3 but in calculating the energy consumed there must be deducted from this amount the figures for September 15, 82.7 tons and for September 16, 53.8 tons, since the short-circuiting switch on the secondary side of one of the current transformers was accidentally closed. The readings of the meters for these two values are therefore not correct.

The number of tons for which accurate values have been obtained is 609.8. The energy consumed by the motor in cutting this amount was 870 kilowatt-hours or an average of 1.426 kw. hrs. per ton.

An analysis of the data tabulated above and a study of the records obtained with the recording watt meter lead to the following conclusions:

a. The motor used is larger than necessary for satisfactory operation of the ensilage cutter used. A twenty horse-power motor would give satisfactory service.

b. The entire outfit is far too large for the average farm need. Two

corn binders and five wagons requiring sixteen horses and an equal number of men were not able to keep the machine in continuous operation. It is believed that this amount of help and equipment is more than could be provided on the average farm.

c. At the prevailing rates for electric power service, farm machinery which could be driven by motor not exceeding ten horse power appears to be the most economical.

MOTOR DRIVE FOR MILKING MACHINE

The dairy barn at the Pennsylvania State College is equipped with a milking machine which can be used to milk as many as four cows at once. This machine is installed so that an electric motor can be used to operate it. This motor will be used to drive other machinery not yet installed, and is rated at ten horse power, one hundred ten volts and twelve hundred revolutions per minute.

The machine is used for approximately seven hours out of twenty-four. The motor input was measured by means of a recording wattmeter for a period of three days or until it was found that the daily power demand did not vary sufficiently to be detected in the meter record.

The input to the motor averaged approximately two and one-half kilowatts. The efficiency of this motor, which is quite old, would hardly exceed seventy-five per cent. at a power input of two and one-half kilowatts. Since no difference could be noticed between the power required to milk one cow or four, a two horse power motor would be ample for this service.

HYDRO-ELECTRIC PLANTS, LANCASTER COUNTY

Farmers are eager to have electricity. This is evinced by the fact that there are several small cooperative hydro-electric plants in Lancaster County. These plants are comparatively new, having been in operation only a year or two. I visited two of these in company with Mr. J. C. Dickerman, assistant director of the Giant Power Survey. The following are a few notes which I made:

Power installed by J. Clarence Reist in cooperation with several neighboring farmers about one mile from Mt. Joy.

On Big Chiques Creek, at an old mill site.

Concrete dam, 92 feet spillway, about 130 feet total length, 10 feet wide at base, about 8 feet high.

Concrete wheel pit, containing a Fitz water turbine (Hanover, Pa.) of 15 H. P. rating, 27″ diam., 8′ 6″ head, belted to a 6 kw., 110 volt, D. C. generator.

Two wire system, leaves power house as bare copper #0 for 1,200 feet; #2 bare for 1,600 ft. and #6 bare for 1,200 feet.

Supplies 6 farm families with all current wanted for lighting, washing machines, electric irons, and small household water pumps.

The cost of providing material and building dam and power house and erecting pole lines was stated as $5,500. All the men working on the construction were paid by time, $3.00 per day—mostly or all native labor from the

farms interested. Farmers take turns weekly in inspection and oiling the machinery.

FIG. 5. HYDRO-ELECTRIC PLANT, NEAR MT. JOY, PA.
This plant was built by several Lancaster County farmers. Description given in the report. It is situated on the Big Chiques Creek.

This installation put in about 1923 has been running just about one full year.

The cooperators	*Lights*	*Washing Machines*	*Water System Pumps*	*Irons*	*Sweeper*	*Motor*
Henry B. Eby	50—60	2	1	2	1	
Hiram B. Strickler	60	1		1		¾ h. p.
Simon Hertzler	60	1		1		¼ h. p.
Raymond Davis	?	1	1	1		1¼ h. p. (milking)
Harry W. Miller	?	1	1	1		
J. Clarence Reist	?	1	1	1		¾ h. p.

This installation gives all the lighting and domestic service wanted except the use of electric ranges or motors above 1½ h. p. The farms and out-buildings appear to be liberally wired and equipped with lights. This power plant is located within 360 feet of trolley line and power lines on trolley poles.

Hydro-electric plant, charge of Alvin Reist, near Mt. Joy.
Situated on Little Chiques Creek.

Concrete dam, about 50 ft. spillway, plus ends, about 100 ft. long, 9½ ft. wide at base, 1 foot on top. Concrete wheel pit.

Fitz water turbine 24″ diam. operates under 7′ 8″ to 8′ head (about 10 h. p.)

Belted to 4 kw., 110 volt, D. C. generator. Water wheel governor.

Serves 5 houses with light and incidental power equipment; has been running two years. The owners are: E. H. Engle, J. T. Guider, Allen Brubaker, Horace Detweiler and Alvin Reist.

All have washing machines and electric irons. Other equipment connected:

1—¾ h. p. motor for milking machine.
1—¾ h. p. motor for deep well pump.
1—½ h. p. motor for "Leader" water system.
1—1/3 h. p. motor for Duro water system.
1—1/6 h. p. motor for Fairbanks Morse water system.
Vacuum cleaner. Blowers for furnace using fine coal.
Dam, power house, wheel and generator installed, cost $2,500.
Use bare #0 copper distributing wire.

FUTURE OF RURAL ELECTRIFICATION

I. Water supply. One of the greatest needs of the farms of Pennsylvania is an adequate water supply. Only 46,402 of 200,000 farms have water piped to the farm buildings. Wherever electricity is available one of the first additions to the farm is a water supply system. Power pumping enables the farmer to get safer water at greater distances from possible pollution than would be otherwise possible, and to store it under pressure.

II. Sewage Disposal. With the installation of a water system on a farm, the problem of correct sewage disposal follows. There is widespread interest throughout the State in the septic tanks system of sewage disposal. These septic tanks are following the installation of water systems.

When the investigations were started we did not realize the important influence which electricity is having and will have upon the water supply and disposal of wastes on the farms of Pennsylvania. This was suggested later by a prominent farmer, Mr. Henry B. Eby, near Mt. Joy, Lancaster County, Pennsylvania. We visited his home and found that he had an automatic water system operated by electric current. He also had a septic tank for disposing of the sewage from his home. Mr. Eby said in substance, "I consider the matter of an ample supply of pure water under pressure and correct sewage disposal one of the necessary features of the country home." He further stated that, "As soon as we began thinking of a water system we began to consider the improvement of the supply. When the system was installed we had a sewage problem on our hands which had not been considered before this time. We then began studying this question and soon had a septic tank system built."

On getting this idea of a thinking farmer I returned to the Brubaker farm and found that one of the first pieces of electrical equipment in that

home had been a water system. Following its installation and the bathroom was the sewage disposal system.

III. Fire Prevention and Protection. The fire losses on the farms of Pennsylvania range between 2 and 3 million dollars each year according to Major C. M. Wilhelm, Chief of the Fire Prevention Bureau of the State Police Department.

Electrically driven water pumps will bring fire protection in some degree to farm property. With the constant pressure features of present day water

FIG. 6. WATER SYSTEM ON DALE FARM NEAR STATE COLLEGE, PA., CENTER COUNTY

Mrs. Norman Dale shown oiling the machine. She says that is all that is needed. She uses an electric range. It costs about $3.50 per month to operate.

supply equipment, every farmer could be protected with an automatic sprinkler system.

MUCH WORK TO BE DONE

Before Rural Electrification can be placed on an entirely successful basis a great deal of research work must be done.

First, a satisfactory rate must be worked out.

Second, much of the machinery now in use must be redesigned, improved in construction, refined and made automatic as far as possible. Electricity has wonderful automatic possibilities. The present day belt driven farm machinery has very few automatic features. This situation must be improved for it is not profitable to use a power which has automatic possibilities with machinery which is not automatic.

An example of this is the farm water system. Before electric drive was common these outfits were manually operated. Now all electric water systems are automatic if the owner so desires. With electric power most of the farm machinery can also be made smaller, thereby costing less to the farmer and requiring less space for installation.

Feed grinding, for instance, might be done with very much smaller mills than are being used at present, if they were automatic. Such machinery might be arranged with an automatic feed, and with a magnetized belt to remove metal from the grain which would damage the machinery. Such a mill when perfected could run during the night or other time when the load on the line is small.

With reference to size of machinery: On the John Dale farm near State College a pressure water system is used. On inquiring into it's operation Mr. Dale said the pump works only a little every day or so. The outfit is serving a long felt need, but it is too large and too expensive for that particular farm. Such instances as this indicate that farmers are generally not well enough informed as to the purchase of machinery.

The problems of Rural Electrification are numerous and development is going to be very rapid in securing service, particularly in sections within easy access to power lines. Research must be as rapid in order that Agriculture may derive the full benefit from the use of electricity. Therefore, it is absolutely necessary that the Giant Power Survey Board be continued in order that the work, so ably outlined and prosecuted to date, may be finished, giving to the farmers of Pennsylvania a real knowledge of the use of electricity.

II. FARM ELECTRIC LIGHTING UNITS

BY JUDSON C. DICKERMAN

Assistant Director, Giant Power Survey

That a considerable number of farmers have appreciated of late years the advantage of some form of lighting system in their homes is shown by the large number of such plants known to have been installed. The general use of small gasoline engines and automobiles led first to make-shift devices, followed shortly by small complete lighting units being put on the market. One of the earliest and most widely known manufacturers put his first machines on the market in 1916. A trade publication stated the output in 1920 of such plants to be about 100,000, valued at $60,000,000, made by 75 different manufacturers. At the present time it is estimated that there are about 225,000 such individual oil engine driven lighting plants in use in the United States. Bulletin No. 37, issued November 6, 1924 by the Pennsylvania Department of Agriculture, states that recent figures compiled by that Department, show 86,411 Pennsylvania farms possess gasoline engines, exclusive of tractors, and 18,277 have electric light service. The latter includes electric service from central station companies, variously estimated at from 8,000 to 11,000, leaving from 10,000 to 7,000 farms having individual plants.

The great majority of farm lighting units consist of single cylinder gasoline or kerosene engines of 2 to 4 H. P. direct connected to 32 volt electric generators of ¾ to 1¼ kw. capacity, which in turn are connected to storage batteries of about 160 ampere capacity each. Automatic devices are usually provided to start and stop the engine with the load, small consumptions of electricity being supplied from the storage battery, the engine running to take large demands or to recharge the battery when required. 32 volt service permits of the most economical investment in the battery, but requires nearly four times as heavy house wiring as is needed with 110 volt supply.

A typical machine rated at ¾ kilowatt capacity, capable of supplying fifteen 50 watt, or thirty 25 watt lamps, or two or three lamps and an electric flat iron, costs with its battery about $450.

A machine complete with battery, with a rated capacity of 1¼ kw. will cost $525. A good concrete foundation and battery rack will cost an additional $25.00. The battery itself will cost, to replace, about $200. The cost of house wiring, fixtures, etc., is not included, neither is any allowance for the value of the space within a building required to properly house the lighting plant.

Such plants do not permit of the operation of motors above ½ H. P. in size, nor the use of electric heating or cooking devices larger than an ordinary electric iron or toaster. With the usual low voltage, economical distribution is limited to a distance of 500 feet from the generator. The service is therefore limited principally to lighting, which may be assumed as totalling 25 kilowatt hours a month on the average.

The life of the battery may be taken on an average at 3½ years. Many batteries not properly cared for are worn out in two years or less. Occasionally one well cared for and lightly used will give a passable service for five or six years. The battery is very necessary for satisfactory service, and at the same time, it is the shortest lived and most expensive part of the equipment.

The actual cost of the electric service obtained from such plants is affected greatly by many factors, most of which are not ordinarily measured and recorded by the owner. A meter to record consumption in kw. hours is practically never installed. The gasoline, kerosene and engine oil may be shared from the same supply cans as serve the owner's auto, tractor, power engine, or cook stove. The capital charges, interest and depreciation, are dominating costs. Depreciation and maintenance, especially of the battery, are greatly affected by the amount of use and particularly the care given the equipment.

Some investigations have been made by the Rural Lines Committee of the Wisconsin Utilities Association, published in 1923, and by the Extension Service of the College of Agriculture, of the University of Wisconsin and published in a pamphlet entitled "Turn on the Light" (Cir. #163, July 1923).

A reasonable cost of service from farm lighting plants for comparison with costs of service furnished by central stations, may be arrived at as follows:

Cost of lighting plant installed (not including housing or house wiring) ready to operate $475.00.

Life of plant—Battery, costing $200, 3½ years; Engine, generator, switch-board, foundations, etc., $275, a composite life of ten years, (see foot note.)

Composite life of entire plant, 5.6 years.

Consumption of fuel, 0.3 gal. per kwh.	@20¢/gal.
Consumption of lubricating oil, .06 qt./kwh.	@25¢/qt.
Minor repairs, maintenance and supplies per yr.	$5.00

Consumption of 25 kwh. per month, or 300 kwh./year.

Annual interest and taxes @ 7% on $237.50, (average value over 5.6 years)	$16.63
Depreciation (straight line) $\frac{1}{5.6}$ of $475	84.82
300 kwh.; 90 gals. fuel at 20¢	18.00
300 kwh. 18 qts. oil at .25¢	4.50
Supplies, maintenance and minor repairs	5.00
Total cost of 300 kwh. utilized yearly	$126.95
Or, per kwh.	42.3 cts.

Note: This depreciation may appear high. It includes besides mere mechanical depreciation a very considerable factor for obsolescence, due to a marked decline in number of manufacturers in the business, making maintenance difficult, and the probability that central station service will be available and substituted in many cases within the next ten years.

If the above plant were to supply an average of 50 kwh. a month or 600 kwh. a year, (which would mean at times utilizing its full capacity), the cost per kwh. would be .... 25.7 cts.

Thus it is evident that such small plants furnish electric service at extremely high cost per kw. hour, where depreciation and obsolescence are properly provided for even without charges for the labor involved in ordinary care and supervision. The actual daily operating cost for fuel, oil, and minor repairs is close to 9 cents per kw. hour omitting altogether interest and depreciation. That the farmers have installed and operated so many plants is an indication of the appreciation of the convenience, safety, and better lighting which is possible when electric current is available. Such plants, however, must be shut down whenever current from commercial distribution centers of low cost generation is available.

III. SUGGESTIONS FOR RURAL HOUSE WIRING

By George H. Morse

Service Connections

The Transformer End.

When electricity is to be supplied to a farm, a transformer is hung on the cross arms at the top of a pole located near to or upon the edge of the

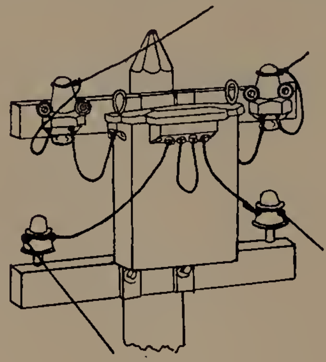


Fig. 1

premises. (Fig. 1) Two wires called primary, deliver electric energy through two fusible primary cutouts one of which is shown at either end of the upper cross arm in the picture. Electricity which enters the transformer by way of one of the two primary wires merely passes through a coil of wire and comes out by way of the other primary wire. This coil of wire is insulated so that no electricity can escape from it to other parts of the transformer on its way through. It however has a strong magnetizing effect on an iron core when electricity is passing through, and the magnetism it induces causes electricity

to flow in another coil of insulated wire, the ends of which are attached to a pair of wires known as the secondary. These secondary wires are shown attached to insulators at two ends of the lower cross arm. It is these secondary wires that extend to the farm buildings and actually deliver the energy to the farm circuits.

The fusible plugs referred to in connection with the primary circuit contain short lengths of easily fusible metal which melts and opens the primary circuit in case bare spots in the secondary wires momentarily touch each other with no device between them, such as a lamp or motor, to absorb the electric energy. Under such conditions the wires of both primary and secondary would instantly become very hot were it not for the action of these primary fuses. In most cases smaller fuses installed within the premises act first and relieve the situation but if they do not do so, and a primary fuse is "blown" as it is called, then the premises will be without current until a

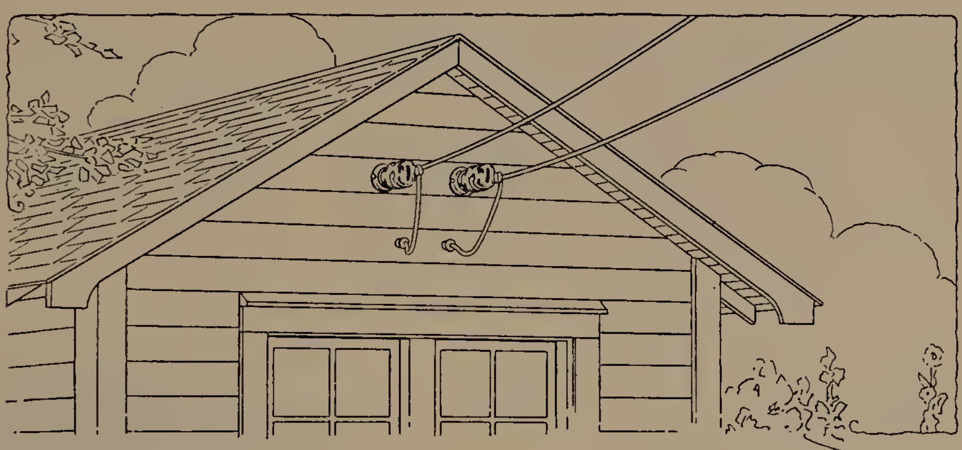


FIG. 2

lineman arrives to replace the primary fuse. A transformer is used because it is the best means of changing the electric pressure from say 4,800 volts needed on the primary to 110 volts desired for the secondary. The two secondary wires which lead into the premises, together with their supports and attachments at the building end up to and including the service switch are called a "service." The type of service we are describing is known as single phase.

A large farm may find that there are three wires running into its premises from the transformer in which case it has either a "Three phase service" or an "Edison three wire service," which are two quite different things, the former being adapted to serve lights and three phase motors, while the latter is only suited to operate lights and single phase motors.

The Building End

Now let us consider the building end of the service. Fig. 2 shows the

wires attached to a house by means of a pair of porcelain strain insulators, each of which has a screw already attached as bought. Fig. 3 shows how

FIG. 3.

such insulators are applied when they are to be screwed into soft wood. The screw is started by jabbing it into the wood, or hitting the insulator lightly with a wooden mallet. It is then screwed home, using a screw driver or spike as a lever arm.

In Fig. 2 the wires are seen to be bent down to form "drip loops" and then carried upwards, in a slanting direction through porcelain tubes into the interior of the house. When service wires are long and heavy a stronger form

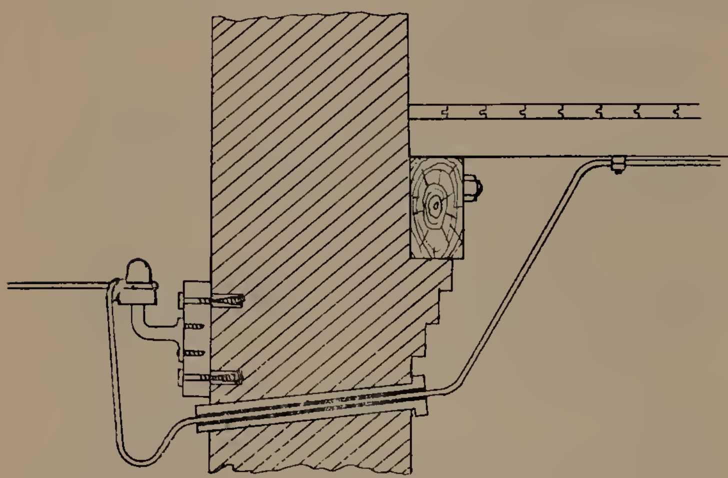


FIG. 4

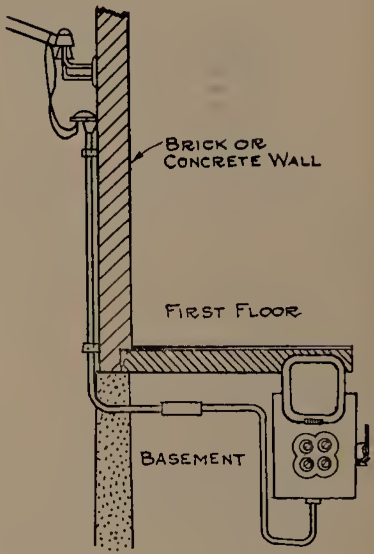


FIG. 5

of support is obtained by means of iron brackets attached to the wall by means of through bolts or expansion bolts, the latter shown in Fig. 4. In this illustration the porcelain tube has its head on the inside of the building which is the correct way.

The *National Electrical Code* 1923, Article IV, 404 Entrance states:

a. All service wires shall enter the building at a point as near as practicable to the location of the service switch. They shall be rubber-

covered from the point of support on the outside of the building nearest the entrance to the service switch and cutout, and shall not be smaller than No. 10.

The Code then says:

It is recommended that conductors entering buildings from overhead lines be encased in approved rigid metal conduit having weatherproof threaded joints and equipped with approved service head, and that all wires of the same circuit be placed in the same conduit.

A service such as this recommendation has in mind is shown in Fig. 5. It is considerably more costly than the simpler kind described above and not insisted upon by the inspectors. It seems probable that the cheaper sort will continue to be most commonly used in rural districts for a long time to come, since many years of experience have shown it to be sufficiently good and dependable in most cases.

The Service Switch, Meter and Distribution Cabinet

In times past these three items were, as installed, quite separate and only connected together by the electric wires. At the present time a single iron box can be had which contains the service switch and service cutout, and several branch circuit cutouts, and above which the meter is mounted by means of a rigid sheet metal collar. A combination of this sort, which has been adopted as standard by a number of makers and which is called the "Universal Type" of safety switch is shown in Fig. 6, with the hinged door

FIG. 6

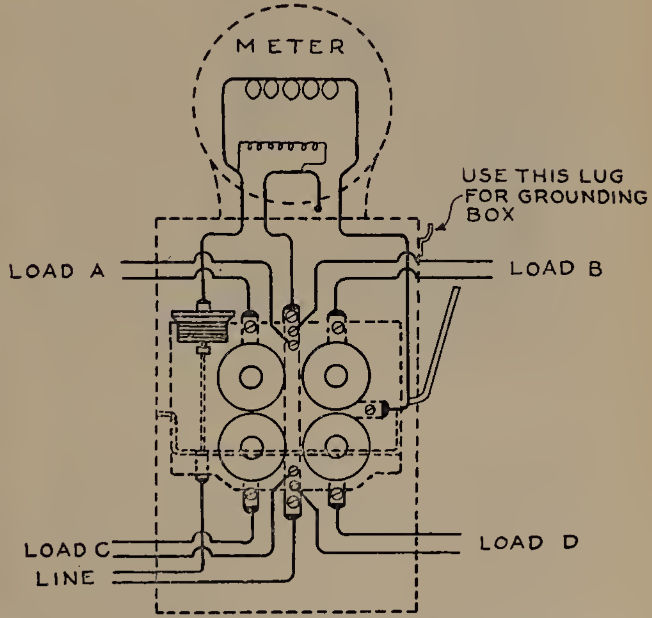


FIG. 7.—2 Wire Solid Neutral Switch—Four, 2 Wire Branch Circuits

covering the branch circuit cutouts swung open. The whole front of the box is also hinged and constitutes a door which may be padlocked in the closed position which keeps any unauthorized person from tampering with the service switch and meter connections; members of the household may, however, at any time open the smaller door to replace a burned out branch circuit fuse. The service switch itself is mounted on the reverse side of the porce-

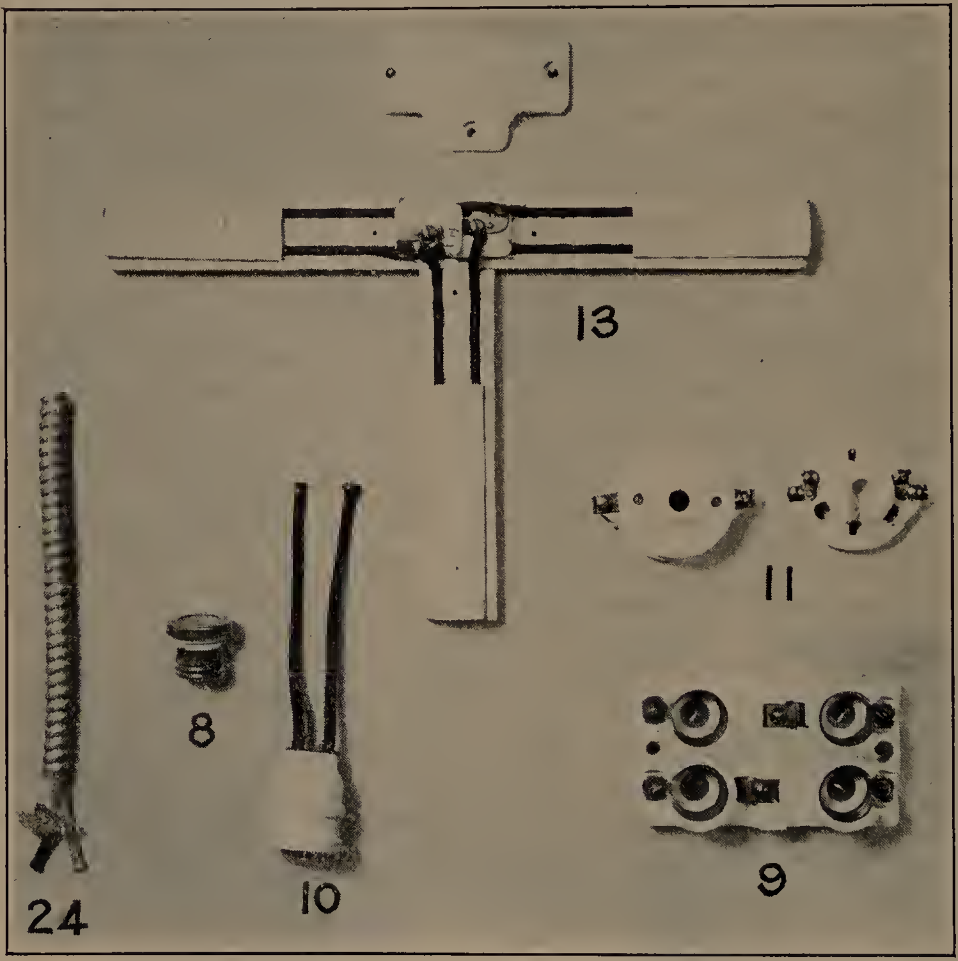


FIG. 8, 9, 10, 11, 13, and 24

lain base which carries the branch circuit cutouts. The service cutout is mounted on the upper edge of this same porcelain base but in position such that it cannot be reached unless the whole front of the box is swung open. The switch can be opened and closed by means of a crankarm on the outside of the box. Fig. 7 shows a diagram of the circuits of this safety switch combined with those of the meter. The cutouts are of the so-called Edison-plug type. In this type the fuse is contained in a porcelain cup (Fig. 8) fitted with a brass screw.

The fuses are not replaceable and when one is blown the whole plug is thrown away and a new one provided. It will be noted from Fig. 7 that the main line and the branch lines are each provided with but one cutout to each pair of wires. The unprotected wires are shown all connected to a common central conductor which is, either within the box, or at some point outside the box, connected to the ground by means of a ground wire attached to a water pipe which extends through the basement wall into the damp ground outside of the building, or to a substantial iron rod driven several feet into the damp ground outside. The switch box is also connected to the ground, which may, so far as the underwriters' inspectors are concerned, be by means of the same ground wire which has been above described, a lug attached to the box being provided inside for this purpose. If a separate ground wire for the box is used it is attached to the external lug at the righthand upper corner. The "Universal Type" of Safety Switch which has been described was designed to meet the following clause of the "National Electric Code" 1923,

> Article 8:
>
> 807 (b) By permission of the inspection department, on systems having a grounded neutral, or having one side grounded, and where the grounded conductor is identified and properly connected, 2 wire branch circuits may be protected by a fuse in the ungrounded wire, no fuse being placed in the grounded wire. Otherwise 2-wire branch circuits shall be protected by a fuse in each wire.
>
> Article 6:
>
> 801 (b) For conductor sizes No. 8 and smaller the neutral conductor on all 3-wire circuits and one conductor on all 2-wire circuits shall have a continuous identifying marker readily distinguishing it from the other conductors. For rubber-covered wire the identification shall consist of a white or natural gray covering. When one of the circuit wires is to be grounded, the ground connection shall be made to this identified wire. See Fig. 24.)

It is safe to assume that, in the absence of local rules to the contrary, made by a central station company supplying the current, the inspectors will approve a grounded service such as has been described with the main and branch circuits having cutouts in the side attached to the ungrounded part of the service. If local requirements make it necessary to ground neither side of the branch circuits, the Universal type of safety switch can still be used but it will then accommodate two branch circuits instead of four. Such a switch can be purchased at from $5.00 to $6.00 and offers the cheapest and best approved means of serving four or less branch circuits. Where more than four branch circuits are to be supplied an inclosed safety service switch, of similar pattern should be used but without provision for branch circuit cutouts and connections. Branch circuit cutouts and connections are in such a case provided in a separate iron box known as a distribution cabinet. A steel box, of any convenient size may be used so long as it allows several inches clearance all around and in front of the porcelain, plug fuse cutout

bases which are the sort most likely to be selected. A double pole, double branch porcelain base cutout like Fig. 9 can easily be adapted for the single pole use we would wish to make of it by connecting all lugs between the plug sockets together and to the ground wire. Each block would then accommodate four branch circuits.

Cost of Service Connections

First Example

House within 125 feet of transformer pole. Two wires extend from cross arm on pole to special bracket insulators on house, and are provided with drip loops and carried through wall in porcelain tubes.

#6 Weatherproof wire 275 feet @ .017	$4.67
#3 Rubber covered wire 40 feet @ .03	1.20
Secondary rack with two insulators mounted on transformer pole	1.00
Wall bracket with glass insulator 2 @ .15	.30
Bolts for attaching wall brackets 4 @ .10	.40
Porcelain tubes 2 @ .10	.20
Porcelain knobs 6 @ .02	.12
Safety enclosed service switch arranged for four branch circuit identified wiring	8.00
Labor of installation	8.00
	$23.89

Second Example

House about 250 feet from the transformer pole so that an extra pole must be purchased. The cost will include the above and additional items as follows:

Forward from 1st. estimate	$23.89
Pole, 30 foot chestnut with arm and insulators	10.62
#6 Weatherproof wire 250 feet @ .017	4.25
Labor handling and setting pole and stringing additional wire	9.00
	$47.76

WIRING THE HOUSE

The Underwriters Inspection Bureau

The Underwriters Association of the Middle Department, 316 Walnut Street, Philadelphia, maintains a bureau of electric inspection which covers all of the State save Allegheny, Chester, Bucks, Montgomery, Philadelphia and Delaware Counties. It keeps 45 inspectors busy and aims to inspect every job of electric wiring put in, even on most remote farms. Its requirements are those of the National Electrical Code of 1923. Inspection is as exacting in the country districts as in town residences. This code of rules can be had for the asking by any farmer and contains all that he needs to know to do his own wiring but he will doubtless experience difficulty in comprehending the printed directions since they are quite technical. The electrical inspection department of the Middle Department desires to be

consulted on any and all electrical problems as applied to correct interpretation of the rules in the 1923 edition of the Code. Commentaries by various authors attempt to explain the code in greater clarity and detail, but even with these in hand, one who does not make a business of electric wiring is not likely to have his work passed without the necessity of making corrections, unless he confines himself to a very simple installation. Such an installation will now be described.

A Safe Method of Wiring Farm Buildings

The simple form of wiring for 110 volt branch circuits designated as "Open Wiring" could usually be accomplished by a farmer acceptably to the inspectors, if the following directions are adhered to. See Fig. 12.

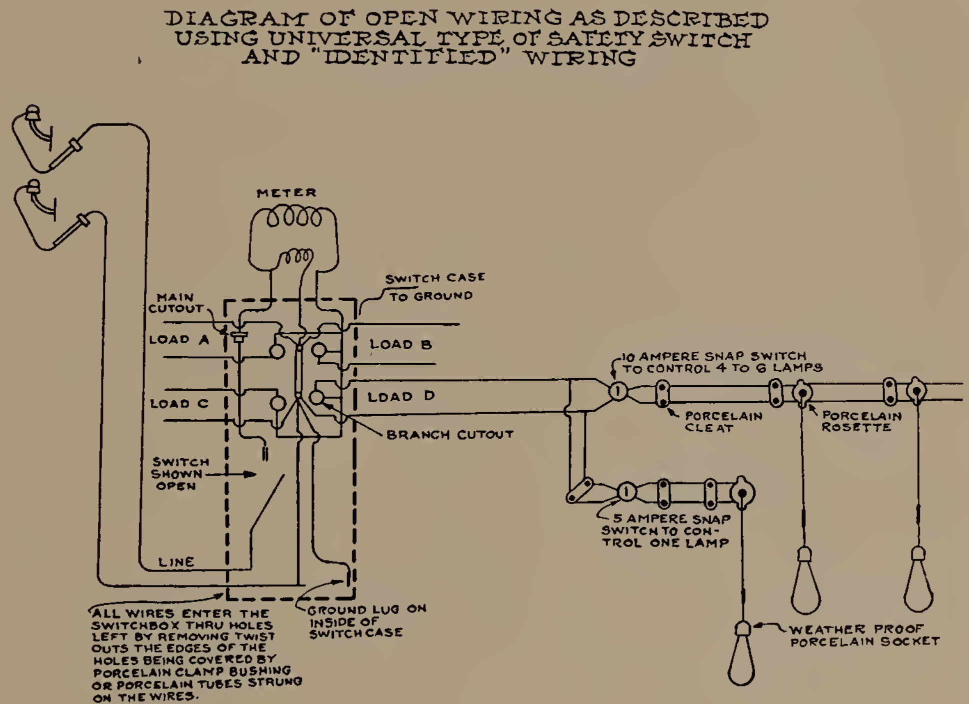


FIG. 12

Supports to be porcelain cleats or knobs so designed as to separate the wires at least 2½ inches and maintain them at least ½ inch from the surface wired over. Wire to be approved rubber covered. Branch wires to start from a Universal type safety switch or steel distribution cabinet. In either case porcelain tubes, or clamp bushings, should be threaded over the wires at the points in the sides of the switch or cabinet where they enter, and if tubes, these should be securely taped to the wires which they cover. The switch or cabinet should be attached to a dry wall near the point where the service wires are to enter the building. If a distribution cabinet is used, fused porcelain branch blocks are to be attached to the back inside with

several inches in the clear about all metallic parts. Edison-plug fuses are the most convenient.

Use number 14 B & S gauge wires for circuits designed to supply 3 or 4 outlets and number 12 for 4 and not to exceed 6 outlets. This is fewer lights per circuit than the underwriters rules allow but to follow these directions will insure good voltage regulation and little chance of overheating the wires.

All wires to be in plain sight except where rising vertically through a floor where they should be protected by a substantial boxing, extending upward to a point not less than 7 feet above the floor, said boxing closed at the top except for holes carrying porcelain tubes through which the wires pass. The boxing may be of wood and should provide an air space of not less than one inch about each wire. Porcelain tubes should cover the wires where they pass through the floor or a partition. As a good rule, place a cleat or knob within a foot of where the wires enter a distribution cabinet, pass through a floor or partition or serve an outlet.

Wires exposed to mechanical injury should be suitably protected by running boards not less than ½ inch in thickness and 3 inches in width or by guard strips not less than ⅞ inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring. By running board is meant a board to which the insulators are attached and which takes the place of a wall over which the wires extend.

The wires should be continuous and of one size from the safety switch or distribution box, above described, to the circuit switch and from this switch to the outlets which are to be supplied with current although this may be accompished by attaching branch wires, always of the same size, as the wires which leave the box, all joints being carefully soldered and covered with tape.

The pair of wires of a single circuit as it leaves the distribution box, had best be carried intact to a convenient point where they enter a double pole, 10 ampere, porcelain base, snap switch. In some cases it will be desirable to attach two such switches, side by side, one to control say half a dozen lights and the other, one or two lights, the latter switch being of 5 ampere capacity. This is all illustrated in Fig. 12.

At a lighting outlet the wires should be attached to a one or two-piece, fuseless porcelain rosette, Fig. 11.

Pendant weatherproof, keyless porcelain sockets Fig. 10 are cheap and reliable and come already wired with several inches of wire protruding. Such sockets are adapted to either indoor or outside use. The wire ends protruding from the socket may be soldered and taped to the two conductors of a 16 guage, standard, flexible rubber insulated, cotton covered lamp cord, the other ends of which are connected to and supported by the rosette above referred to. The cord should be of such length that the socket, carrying the lamp, will hang at the desired level. Any excess of cord, necessitating hooking up or supporting by any means, other than the rosette to which it is attached, should be avoided as a source of great fire hazard. Portable attachment cords for lighting purposes should not be used if possible to do without them.

If a range is to be used the service wires from the pole to the distribu-

tion box should never be smaller than number 4 B & S gauge, and a special circuit of this sized wire should be installed from the service entrance switch or cabinet to the range, no other devices being attached to this circuit except the range.

The above description of a method of open wiring was subjected to critical examination by inspectors of the Middle Department and found satisfactory as it now stands.

There will be those who feel that they have sufficient mechanical skill to do an acceptable job of concealed wiring and who prefer this type of wiring for use in their houses. The various kinds of such wiring will now be briefly described.

Wood Molding

Wiring in wood molding attached to the outer surfaces of walls and the under surfaces of ceilings, while not usually classed as concealed, never the less offers a sightly means of hiding the wires from view. The "National Electrical Code" refers to wood and metal moldings as raceways. It states:

> Article 5:
>
> 504 (b) Wooden raceways shall be coated, externally and internally with two layers of waterproofing or shall be impregnated with a moisture repellant. The raceway shall be composed of two parts, a backing and capping, and shall afford suitable protection against abrasion of wires. It shall be so constructed as to thoroughly encase the wire, having a barrier of not less than ½ inch in thickness between wires, and having exterior walls which under grooves shall be not less than ⅜ inch in thickness, and on sides not less than ¼ inch in thickness.

It is recommended that only hardwood be used. The backing, or part of the molding attached directly to the wall has two parallel grooves in its face and in these the wires are laid. The capping is merely a flat cover tacked to the face of the backing over the wires, Fig. 13.

It is now uncommon to install a complete wiring system in wood moldings but such construction is often used in connection with other kinds of wiring.

Wooden molding cannot be used in damp places nor in work out of doors. If occasion arises for using it against the inside of an exterior concrete or brick wall liable to sweat a backing at least ⅞" thick should first be attached with its grooves against the wall and another piece of backing, in which to run the wires, should then be attached to the first piece, treating the underlying backing as if it were an original wall surface.

Wooden molding is not allowed in concealed places. Where the wires are to pass through a floor or a wall the molding should there end and the wires alone be passed through, encased in porcelain tubes long enough to reach the entire length of the holes. When the wires are carried through a floor a cast iron or wooden "kick-box" should be applied to protect the wooden molding where it commences to rise.

Wires must be continuous from outlet to outlet if they are encased in wooden molding. When it is desired to make a splice in the wire between two outlets the capping is cut away and a porcelain device mounted on the back-

ing. This device is called a taplet. It consists of two parts, a base containing metallic parts for making connections and a cover part to conceal these connections, Fig. 13.

The molding should be mitered at corners like picture frames and it is frequently possible to lay it out in a regular pattern on the ceiling, adding an unused run of the molding if needed to complete the pattern. It is often applied on the walls near the ceiling taking the place of a picture molding.

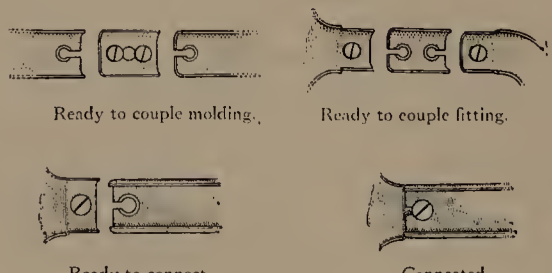
A variety of porcelain devices such as lamp and plug receptacles, rosettes, snap switches and adapters to pass from molding to rigid or flexible conduit have been especially made for use with wooden molding and are easily obtained.

Either nails or screws may be used in attaching the backing to a wall, the capping usually being attached to the backing with small headed nails.

Metal Molding

A metal molding which has been widely used for running branch circuits in offices and other show places where neatness and good appearance are important is made in two sizes. The larger of these has a backing a little over a half an inch deep and an inch wide. It will take four No. 14 wires, or three No. 12, single braid wires. The backing of the smaller molding is a little less than half an inch deep and five eighths of an inch wide. It takes two wires only. The sections of these backings are shaped like a very wide letter U with the top arms of the U drawn toward each other. The cappings for these moldings are also U shaped in section but not nearly so deep. They are snapped firmly in place over the backings after the wires have been inserted. These moldings come in bundles 8 ft. 4 inches in length and enough pieces to make 100 feet of molding. The material used is sheet steel which has been heated in contact with zinc dust until its surface is so alloyed with zinc that it effectively resists action of moisture to rust the underlying steel. The surface has a soft dull gray color which harmonizes with almost any background and which takes either oil or water paint with ease.

The larger molding has keyhole shaped slots at its ends by means of which the couplings are made between lengths, and to the large variety of fittings which have been developed to use with it, Fig. 14. The backing has holes



Ready to couple molding.

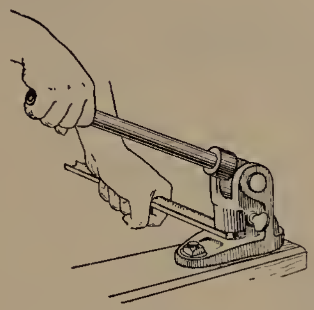
Ready to couple fitting.

Ready to connect molding to fitting.

Connected.

FIG. 14

about two feet apart by means of which it is attached to walls and ceiling. When less than a length must be used it is cut off with a fine toothed hacksaw or by means of a simple sheer on the order of the machine shown in Fig. 15.



Cutting key hole slot at end

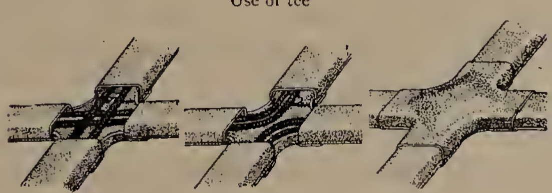
FIG. 15

The machine there shown is, however, a punch which is used to cut the key-hole slot in the end of a piece which has already been cut in two.

The various fittings by means of which turns, crosses and branchings are accomplished are shown in Fig. 16. While a few of these fittings offer

Use of 90 degree and 45 degree flat elbows and of internal and external elbows.

Use of tee



Use of cross.

FIG. 16

sufficient room for making splices and attachments of wires more suitable fittings for these purposes are shown in Fig. 17. Fig. 18 speaks for itself.

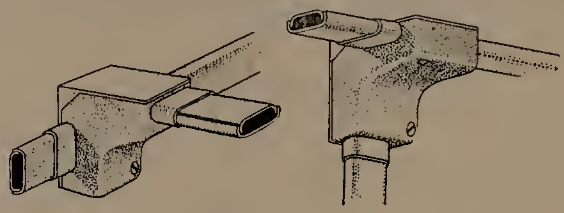


FIG. 17

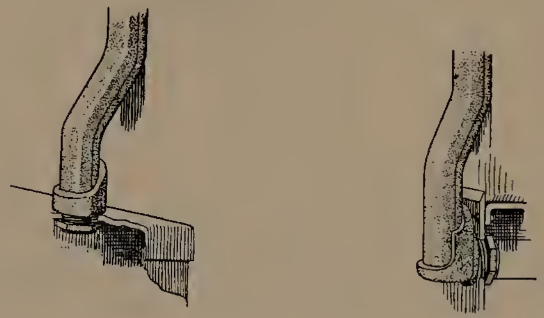


FIG. 18

In passing through a floor it is necessary to introduce a piece of rigid conduit to take the place of the weaker metal molding and this is accomplished by means of adapters shown in Fig. 19.

FIG. 19

As with wooden moldings, porcelain snap switches, lamp bases, rosettes, outlet boxes, etc., are to be had perfectly adapted for use with metal molding.

On the whole this system of wiring is cheap, easily applied and good looking. It is fully approved by the Underwriters' inspectors, when properly installed. It is, however, only suitable for branch circuits which supply little more than a dozen lamps or their equivalent in small motors.

Concealed Knob and Tube Wiring

In New Houses—When a house is building and it has been desired to wire it according to this system a part of the work should be done when the floor joists are exposed and the studding for all partitions has been erected. This first part of the work is called the "roughing-in job." It

consists of running the wires from the point where the distribution cabinet is located to the various points where switches, lights or plug receptacles are to be located, and from the point where the wires enter the building to the service switch. When the service switch is of "Universal Safety" type, this is itself also the distribution cabinet. After the house is finished switches, plug receptacles and light fixtures are installed.

Wiring Plan—It is desirable that a plan of the proposed distribution of

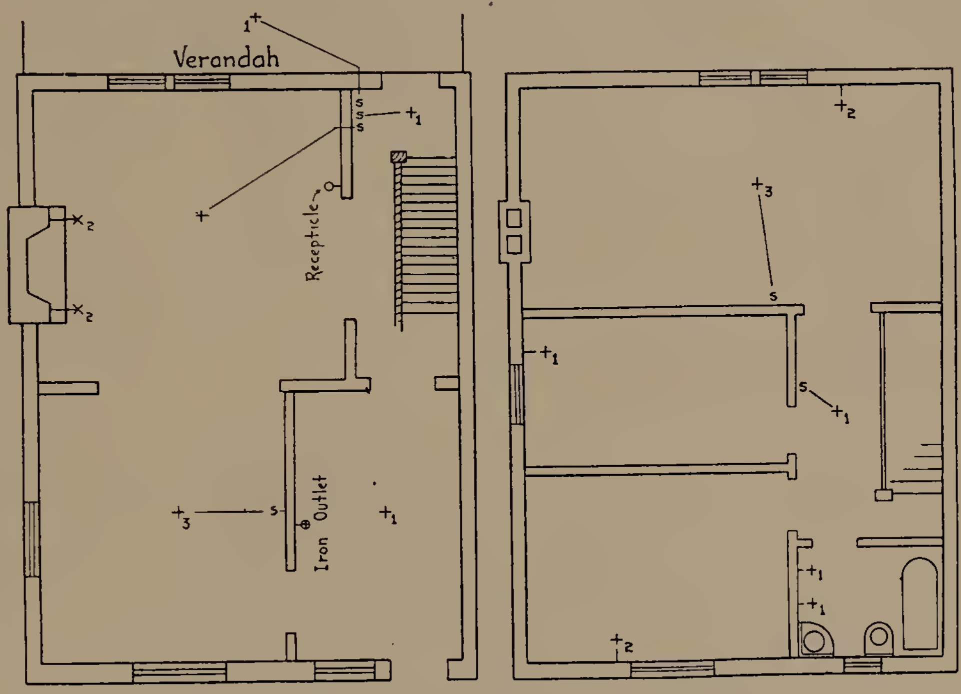


FIG. 20

openings be first made. Fig. 20 shows such a plan for a two story dwelling. The numerals represent the number of lights to be installed in a pendant fixture if in the center of the room or upon wall brackets if shown as coming out from the wall. The letter "S" stands for a switch, usually of the single pole variety; the word "Receptacle" for a plug socket to which an extension cord may be attached, at pleasure, as for a portable lamp stand; and "Iron Outlet" for the point where a flat iron may be attached to the circuit by "plugging in".

Branch Circuits—This system of wiring takes its name from the fact that the wires are carried on solid or split porcelain knobs or threaded through porcelain tubes. The concealed wires must be kept at least five inches apart except at openings. The knobs are attached to joists or studs either with screws or nails. If the latter are used cushion washers, usually of leather, should be placed under the nail head and the nails should penetrate the wood work not less than ½ the depth of the knob. Wire must be of approved rubber covered type.

Where wires are exposed to possible mechanical injury, moisture, or come too close to pipes or to each other, they may be protected by threading the wires together through a piece of rigid conduit which is a kind of iron pipe especially prepared for use with electric wires. Where the wires enter or leave such a conduit these must be provided with a fitting having a separate hole with an insulating bushing for each wire. The conduit must be grounded in accordance with the rules of the Code. Circular loom, which is a spiral tube of tough fiber having an outer woven cotton covering impregnated with a sticky hydrocarbon and dipped in mica, may be used in dry places for like purposes except that each wire is threaded through its own piece of loom. At curves in the wire the knob should be placed so that the screw comes on the inside of the curve. In this position there is less opportunity for the wire to slip out of the groove.

Where wires pass through floor joists they are covered with porcelain tubes which should be long enough to bush the entire length of the holes. The holes in the joists should be bored at a slight angle above the horizontal and the porcelain tubes should be then inserted with their heads in the higher position so that gravity will simply cause them to settle into position and not to drop out of place.

The manner of doing this sort of wiring is clearly shown in Fig 21.

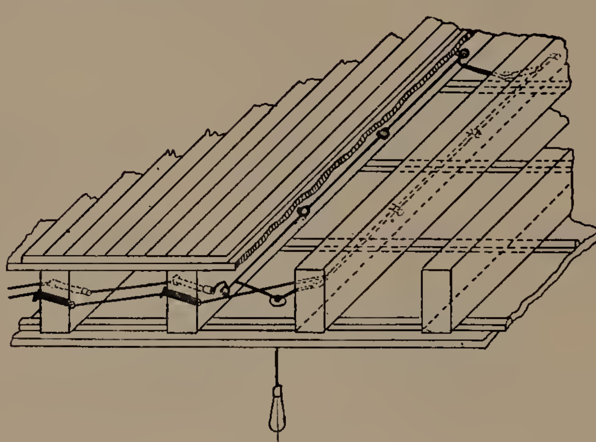


FIG. 21

In boring the holes through the joists a very long bit of the type known as "Ship's auger" is to be preferred, a tube ¼inch in internal diameter requiring a 5/8" bit. In running the wires through these tubes first thread a tube on loosely between each joist and the next until the whole run of wire has been made, then draw the wire tight and insert the tubes in the holes provided for them.

Wires passing from one floor to the next inside a partition should have a porcelain tube bushing the entire length of the hole in the wood work through which it passes and an extra 4" tube strung on above the floor line to keep loose plaster from settling around the wire itself when the plasterers are at work.

Wires running lengthwise on a joist or studding should be run on separate timbers or on opposite sides of the same timber, Fig. 21.

Fixture Outlets—At a fixture or drop cord outlet a ⅞" or 1" board, 6" wide is nailed between the joists with its underside one half to three quarters of an inch back of the lower faces of the joists, Fig. 22. The wires, threaded

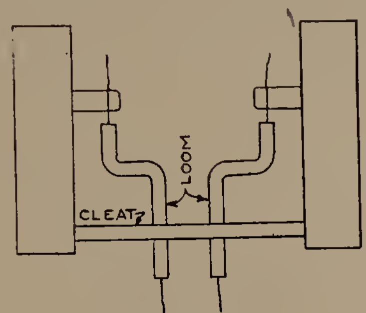


FIG. 22

through circular loom pass through two five-eighths holes bored with their centers 1⅛" apart. Knobs should be attached near the outlet and the wires should be covered with the loom clear up to these knobs. The loom should be long enough to extend below the lower side of the board a distance of 2½", and the wires long enough to extend 6 inches below the board. The board, beside holding the ends of the wires, is provided to support the canopy block which is to support the lighting fixture. When the canopy block is attached screws long enough to reach through the plaster, and into the board should be used. The canopy block is merely a block of wood to which the crowfoot or tripod of the lighting fixture is attached. It has holes bored through it to permit the wires and loom to pass through. When a fixture is installed the ends of the wires coming from the loom are soldered to the fixture wires the joints being covered with rubber and friction tape.

Flush Switches—Either snap or push button flush switches are usually installed with concealed wiring since their faces are flush with the wall surface and hence present a neat appearance. These flush switches must be mounted in iron boxes. There are two sorts of box to be had, one adapted to use where circular loom projects into the box, and one for use with conduit. Concealed wiring with conduit will shortly be described. A flush switch box is mounted between two boards or cleats such as the one described for use with a fixture outlet. If these cleats are nailed flush with the faces of the studding the box will be held in the proper position. Before attaching the box to the cleats the partially loosened disks called "knockouts" or "plugs" should be knocked out of place with a hammer, one opening being made for each wire that is to enter the switch. The distance of the front of the box from the front faces of the studding is made adjustable by the use of ears and screws in the box itself. If the wall is to be plastered the box should be so adjusted that its face extends ½ inch beyond the faces of the studding. As with a fixture outlet

the wires should be covered with circular loom from the nearest knob until they have passed into the box, the loom itself extending into the box, Fig. 23.

Baseboard receptacle and floor outlets should be arranged as has been described for a ceiling outlet with wires and loom extending. After the baseboard or floor boards are in place the switch boxes may be fitted into them, the wires and loom being thrust into the holes in the switch box and the receptacle installed. Where floors are likely to become damp the wires for floor outlets should be run in rigid conduit and water proof receptacles installed in water tight boxes.

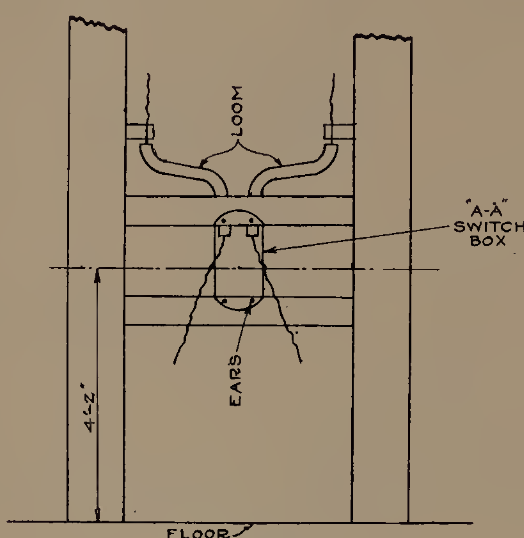


FIG. 23

In a cellar or basement only porcelain lamp sockets should be installed as metallic sockets in this location are dangerous to life. A warning may be here given also in regard to metallic lamp sockets in other parts of the house; never stand in a bathtub or with one hand on a water pipe and attempt to turn on an electric light at the same time. This is sometimes a very dangerous thing to do.

Wiring of Finished House—The wiring of finished houses by means of knob and tube system is not very different from its use in houses which are just being built. The chief difference is found from the greater number of cases, in wiring an old building, where the wires must be drawn through holes in floors and partitions and "fished" up through the walls. In all cases where the wires cannot be clearly ascertained to be at a proper distance from woodwork when drawn tight, circular loom should be drawn over the wire and this should extend from the nearest knob on the one side of the doubtful run to the first knob on the other side. Such provision is allowed only in dry places. In wet or damp places such a run should be made in rigid conduit, both wires to be in the same conduit which should end in proper outlet boxes or have suitable end fittings attached such as have already been described.

Wiring to first floor ceiling and wall outlets of a finished house is accomplished by taking up certain boards from the floor above. If the center of distribution is in the cellar the wires are brought to the second floor through the first floor wall. To do this a short piece of board has to be taken up from the second floor near the wall above the point at which the wires are to rise. Such an opening is called a "pocket." A pocket is opened by first finding a board which, if possible, has an end where the pocket is to be. A putty knife and hammer will serve to cut off the tongue on both sides of the board. A sharp pointed keyhole saw is then inserted in the crack which has been opened by the putty knife, at a point close to a joist, and worked around on its axis, while sawing until it faces across the grain. The board is then sawed off and pried loose with the putty knife or chisel and removed. A cleat is nailed to the joist at the end where the cut was made and when the piece of board is put back into the floor it rests upon this cleat to which it is attached with screws. Having brought the ends of the wires up through the wall from the cellar by fishing for them through the pocket, each wire being incased in circular loom, they are carried out to a point above the opening to be made in the first floor ceiling, or in some cases to the center of a hall running parallel to the wall near which the pocket was cut. This is done by means of knobs on the surfaces of the two joists between which the pocket was cut. It will be necessary to cut additional pockets about four feet apart starting at the wall, in order to attach knobs to the joists and string the wires under the floor to the center of the room or hall. If the hall has been thus reached the wires can be carried forward or backward across the direction of the joists by taking up a couple of boards which extend along the center of the hall. In making such a run it is done by the usual method of stringing the wires through porcelain tubes placed in holes bored through the joists. From such a run under the center of the second story hall floor, wires can be carried right and left, between joists to openings in the ceilings of front and rear first floor rooms. When the house has a space between the ceiling of the second floor and the roof, this offers a convenient place to run wires even if it is necessary to cut a manhole in the ceiling of a second floor clothes closet to get into this space.

Cost of Wiring Finished Houses—The cost of wiring a farm house with exposed wiring on porcelain cleats or knobs should be $2.50 to $3.50 per outlet without fixtures if done by a contractor. The cost of wiring an old house with concealed wires; i.e. run in walls and under floors using porcelain knobs and tubes should be $4.50 to $5.50 per outlet, without fixtures, if done by a contractor.

Wiring in Rigid Conduit—This is the most substantial, safest, and most highly approved type of wiring for all locations whether dry or damp. The conduit itself is a specially prepared iron pipe either treated with zinc externally and internally by the process known as "Sherardizing" or it has been given a protective coating of enamel both outside and inside. Only conduit bearing the inspection tag of the Underwriters' Inspection Bureau is permitted by inspectors, to be used.

The lengths of conduit are coupled together by means of an ordinary

pipe coupling furnished with each length of conduit. It is run continuously from steel cabinet, junction or pullbox to steel outlet boxes or a run maybe terminated by a special fitting carrying an insulating bushing having a separate hole for each wire carried by the conduit. All wires of a given circuit are run in the same conduit and must of course be rubber covered. The wires and their insulation must be continuous from outlet to outlet. Where the end of a conduit enters a box of any sort it is threaded and the hole through which it passes is sufficiently large to admit the threads. A lock nut is however first screwed onto the end of the conduit. The end is then placed in the hole in the box and a "Conduit Bushing" is screwed on. This bushing is a combination nut with a smooth rounded opening which covers the rough end of the pipe where the wires come out and protects them from injury. After the bushing is in place the locknut is backed up against the wall of the box and thus pinches it tightly between the nut and the bushing. The conduit must be well grounded, a grounding clamp which surrounds the conduit and grips it tightly being used to attach the end of a grounding wire. A service of the sort shown in Fig. 5 is the only kind which should be used with a rigid conduit system.

Long radius ells are sold for use with rigid conduit but in many cases it is cheaper and neater to bend the conduit itself. In bending a piece of ½" or ⅝" conduit, a tee-pipe bender, usually called a "Hickey" is used. This is a leverarm or handle with a short, but strong, cylinder, like a piece of pipe, fixed at its end in the same position as that occupied by a mallet head, only of course, the mallet head in this case is open from face to face so that a piece of conduit can be thrust through it. The conduit is then laid on the floor and the operator stands on it with both feet while pulling on the handle of the "Hickey". No more than four quarter bends are permitted in a conduit from outlet to outlet, bends at the outlet not being counted.

A conduit is cut and threaded by means of a pipe vise, wheel cutter and pipe stock and die, the same as water or steam pipe. The inner end of a piece of conduit which has been cut should be carefully reamed smooth, so that no sharp edges will come against the wire when it is drawn in. All openings for fixtures, switches, plug receptacles, etc, have iron boxes, usually set flush with the wall in which the connections are made. Lighting outlet boxes have flat iron covers with bushed holes through which the wires come out to a fixture or a threaded base into which the fixture pipe is screwed. An insulating joint was formerly required at this point but can now be omitted if the screw shells of the lamp socket are connected to the grounded wire of the circuit.

After the conduit is completely installed the wires must be fished into it. A steel fish tape, or "Snake" as it is sometimes called is used. The end of the tape is first bent back to form a small hook and so that the tape will not stick at joints when being thrust forward through the conduit. The tape is pushed through from an outlet to another outlet, and the wires are attached to the hook and pulled back through the conduit. In doing this the ends of the wires first have the insulation scraped off so that a small joint can be made where they are attached to the hook of the fish tape

Friction tape is wrapped over this point, and powdered talcum or soapstone is applied to the tape to make it slip easily in the conduit. In hot weather the soapstone has to be applied to all of the wire to be drawn in.

Armored Cable—There is still another method of wiring which is less costly than rigid conduit and more conveniently and easily installed. It is however not suited to damp places unless the wires have a covering of lead over the insulation. Armored cable usually consists of a pair of rubber covered conductors around which has been spirally wound a covering of steel tape. The armored cable most commonly used is known as "BX" and contains a pair of No. 14 wires. It is used as a substitute for rigid conduit in concealed wiring. In general the same rules apply to both systems. Steel switch box outlets, junction boxes, fixture supports, and ground clamps are of the same type and installed in the same manner for both systems of wiring. "BX" can now be obtained with one wire having a light and the other a dark covering for use in "Identified" wiring, see Fig. 24.

"BX" finds its chief application in the wiring of finished houses. The service is usually made with rigid conduit as also any runs across the cellar. At the point where the wires are to rise through the wall a junction box is installed and the rigid conduit here ends and the "BX" cable begins. If the riser through the walls is to be of ordinary length supports are not required inside the wall, the "BX" being merely strung loosely until it reaches the first outlet box which may be beneath the floor of the second story at the center of the house, the cable having been bent at the wall and carried across under the floor boards.

Special clamps must be applied where "BX" joins an outlet box in order to make the joint electrically continuous as the whole system has to be well grounded as with rigid conduit.

"BX" is preferred to knob and tube work for wiring an old building. It gives better protection to the wires and it is easier to install. In passing armored cable across floor joists it is necessary to take up only one floor board. It should however not be laid in notches in the top of the joists as it is there liable to be injured by nails. Holes should be made through the joists as for knob and tube work, and the cable threaded through them, but of course, without the use of tubes. When the cable is passed parallel to floor joists it is not carried on knobs; hence it is unnecessary to take up pockets when the cable can be fished without doing so.

IV. STUDIES IN RURAL ELECTRIFICATION

BY GEORGE H. MORSE

Waukesha County Wis. Experience

There were on these lines in June, 1924, 234 rural consumers nearly all of whom are farmers. Eighty-two of these consumers replied to a questionnaire which was sent to them by the Giant Power Survey.

The three largest farms reported contain respectively 1200; 640 and 483 acres while the three smallest holdings were 1, 1 and 4 acres.

Table I. Average Characteristics of Farms in Waukesha County.

Total acreage of farm	129
Number of acres usually under cultivation	84
Number of horses	4.3
Cattle (including milk cows but not calves)	23.5
Number of calves	5
Usual number of cows being milked	17.8
Number of pigs	5.8
Number of sheep	9
Number of chickens	129

Waukesha County is 24 miles square and its farms are largely given over to dairying and stock raising. Compared with Pennsylvania counties there is nothing unique about Waukesha County which should make it a better field for rural electrification than some counties in this State. Counting all farm products there are five counties in Pennsylvania which produce greater values every year, per square mile, than Waukesha County. Eight Pennsylvania counties possess greater values, per square mile, in farm implements and machinery, and eleven counties have more cultivated acres per square mile.

Table II. Electric Appliances on Farms in Waukesha Co.

The appliances in use by the 82 farms answering our questionnaire were:

Flat irons	94	Cream separators	16
Washing machines	45	Milking machines	12
Ranges	41	Grills	6
Vacuum cleaners	39	Sewing machines	6
Heaters (Headlight type)	32	Utility motors	10
Curling irons	23	Feed grinders	6
Water pumps	41	Exhaust fans	9
Toasters	21	Water heaters	5
Electric lighted chicken houses	20	Waffle irons	4
Air compressors	19	Refrigerating machinery (Two are large)	4
Desk fans	18		
Hot plates	16	Heaters (Radiator type)	2

Soldering irons	2	Heating pads	10
Bottle washing machines	3	Coffee percolators	8
Bottle filling machines	2	Motor driven piano	1
Mangle	1	Grindstone	1
Clipping machines	11	Brooder	1

In addition to the above appliances there are about a dozen motors ranging from 1 to 10 horse power used in cheese making at the Pabst Holstein Farm No. 1.

Table III. Estimated Use of Electricity by Various Kinds of Farms.

Dairy Farm	20 Cows 265 kwh.	50 Cows 408 kwh.	100 Cows 880 kwh.
Poultry Farm	500 hens 276 kwh.	1000 hens 391 kwh.	1500 hens 572 kwh.
Stock Farm	20 An. Units 197 kwh.	50 An. Units 247 kwh.	100 An. Units 367 kwh.
Grain Farm	25 Acres oats 25 Acres corn 187 kwh.	50 Acres oats 50 Acres corn 227 kwh.	100 Acres oats 100 Acres corn 290 kwh.
Market Garden 10 Acres, and 3 glass houses each 200′ x 30′, 450 kwh.			
Fruit Farm	20 Acres 170 kwh.	50 Acres 175 kwh.	

The following is one of the estimates in detail, from which Table III was drafted:

Dairy Farm 50 Cows

	Kwh
Grain ground, per year 70,000 lbs. at 1 kwh. per 100 cwt.	700
Hay, alfalfa or clover cut and elevated per year, 100,000 lbs. at 2 kwh. per ton	100
Silage, 300,000 lbs. cut ¾″ long, elevated 40 ft. at ½ ton per kwh.	300
Water for cows, 182,500 gallons at 1 kwh. per 1,000 gallons	182
Water for 8 horses, 40,000 gallons at 1 kwh. per 1,000 gallons	40
Water for garden, lawn and washing automobile, 1,000 gallons	5
Water for pigs and young stock	10
Water for home (10 people) at 30 gallons—109,500 gallons	109
Ventilating fans in cow barns 500 hr. at 2/3 kw.	330
Cream separator, 10,000 lbs of butter fat—260,000 lbs. milk churn 200 batches of butter at 50 lbs. each—each batch takes ⅝ hp. and requires ½ hour	42
Lighting of farm yard, barns and outbuildings	340
Lighting of farm house	200
Range	1,500
Fan (Desk type)	16

Toaster	30
Sewing machine	17
Vacuum cleaner	50
Washing machine	50
Lighting in chicken house in winter	50
Electric iron	72
Milking machines	750
	4,893

Average—408 kwh. per month.

The farm wife will doubtless wish to know what will be the cost of electricity provided for her use in the above estimate. At an average cost of 5 cents per kilowatt hour the monthly cost of electricity used in the farm house would be as follows:

	Kwh.	*Cost per month at 5 cents per Kwh.*
Water for home (10 people)	9.1	.46
Lighting farm house	16.7	.84
Range	125.0	6.25
Toaster	2.5	.13
Sewing machine	1.4	.07
Vacuum cleaner	4.2	.21
Washing machine	4.2	.21
Electric iron	6.0	.30
		$8.47

Without the range the monthly bill would be $2.22. This is on the assumption that considerable additional electric energy is used in farming operations so that so low an average cost as 5 cents per kilowatt hour could be obtained.

Table IV. Cost of Electricity for Operating Various Appliances Based on Rate of 10¢ per Kilowatt Hour For Family of Four.[1]

	Cost for 1 hr. (Current on)	Cost for a Month's Use	Basis of Calculation of Cost for a Month's Use
Percolator	4.3 cts	43 cts	Used each morning.
Toaster	5.0 cts	45 cts	8 slices of toast each morning.
Waffle Iron	6.4 cts	26 cts	8 waffles twice a week.
Grill or Disc Stove	6.1 cts	92 cts	Used half hour each morning.
Dishwasher	2.5 cts	38 cts	Used three times each day.

[1]From an article by George W. Alder, E. E., in Good Housekeeping, June, 1924.

Vacuum Cleaner	1.8 cts	22 cts	Used twice each week (all rooms)
Clothes Washer	2.2 cts	20 cts	Used once each week.
Ironing Machine .... (Large, gas heated)	1.7 cts	7 cts†	‡Used once each week for flat work.
Smoothing Iron	5.3 cts	$1.16* 68 cts†	Used once each week.
Sewing Machine	.6 cts	....	
Fan	.6 cts	....	
Room Heater (Radiant type) ..	6.2 cts	....	
Warming Pad	.7 cts	....	

Table V. Power Consumption of Household and Farm Electric Appliances and Machinery

A. General Farm Applications.
B. Dairy Applications.
C. Poultry Applications.
D. Horticultural Applications.
E. Residence Applications.

A. GENERAL FARM APPLICATIONS

	Installed Capacity	*Demand Expected (watts)*	*Probable hrs. use per mo.*	*Ave. Cons while in operation*	*Monthly cons. kwh.*
Bone Grinder (Cutter)	1½ H. P.	1400		750 W.	
Groomer	2 H. P.	1400			
Corn Ear Crusher (1500#/hr)	4 H. P.	3500			
Corn Cracker (60 Bu./hr.)	6 H. P.	5700			
Feed Grinder (50 Bu./hr)	10 H. P.	7000			
Fodder Cutter & Crusher	4 H. P.	3500		2 kwh/ton	
Ensilage Cutter & Blower	8 H. P.	7000		1 kwh/ton	
Fertilizer Mixer (160 A. Farm)	½ H. P.	475	3.5	400 W.	1.4 kwh
Feed Mixer (160 A. Farm)	½ H. P.	475			
Wood Splitter	2 H. P.	1900			
Wood Saw	4 H. P.	3800			
Water Pump	¼ H. P.	250	60	250 W.	15 kwh
Grindstone	½ H. P.	350	8	200 W.	1.6 kwh
Grain Elevator	3 H. P.	2100			
Grain Separator	1 H. P.	700			
Bench Grinder	¼ H. P.	175			
Clipping Machine	1/6 H. P.	100			
Shearing Machine	¼ H. P.	175			
Hay Hoist	4 H. P.	3800			
Baler	8 H. P.	7600		4 kwh/ton	
Blower, forge	1/10 H. P.	70			
Oat Crusher	¾ H. P.	500			
Silo Filler (40 ft.)	15 H. P.	10500		2 kwh/ton	
Straw cutting	½ H. P.	350		3 kwh/ton	
Fodder-cake crusher	1½ H. P.	1050		3 kwh/ton	

*This figure represents the cost of operation where only a hand iron is used.
†These figures represent the cost of operation where hand iron and machine are used.
‡The cost of gas for a month for this use of the ironing machine would be 12c with a rate of $1.00 per 1000 cubic feet.

	Installed Capacity	Demand Expected (watts)	Probable hrs. use per mo.	Ave. Cons while in operation	Monthly cons. kwh.
Threshing					
19″ cylinder	15 H. P.				
32″ cylinder	35 H. P.			(1 kwh per 4 bu. wheat)	
Treatment of Ensilage	35 K. W. (Max)			25 kwh/ton	
Electro-Culture				1.5 kwh/acre	
Plowing					
Meat Curing					
Hay drying					
Wood Preservation					
Root grinder	2 H. P.	1400			
Lathe	½ H. P.	350			
Drill Press	½ H. P.	350			
Air Compressor					
Burr Mill	5 H. P.	3500			
Concrete Mixer (3.5 cu. ft.)	1½ H. P.	1000			
Potato grader					
Portable storage battery	30 W.	30 W.			
Lantern					
Plowing					

B. DAIRY APPLICATIONS

	Installed Capacity	Demand Expected (watts)	Probable hrs. use per mo.	Ave. Cons while in operation	Monthly cons. kwh.
Ice Breaker (3 tons per hour)	¾ H. P.	700			
Ice Cream Freezer (20 qt. cap.)	½ H. P.	475			
Ice Cream freezer & ice breaker (20 quart size)	½ H. P.	475			
Ventilator	¼ H. P.	240			
Elect. Milker (portable, 2 cows)	¼ H. P.	175	3 hrs.	150 W.	½ kwh.
Pipe Line Milker	1½ H. P.				
Babcock Milk Tester	1/12 H. P.	60			
Homogenizer	5 H. P.				
Concentrator	7½ H. P.				
Filler & Capper (Bottle)	¼ H. P.	175			
Forewarmer & Mixer	1 H. P.	700			
Separator	¼ H. P.	175		150 W.	
Pasteurizer (600 gal.)	½ H. P.	350			
Can Dryer	½ H. P.	350			
Bottle Washer	¼ H. P.	175			
Bottle Washer single brush	⅛ H. P.	150			
Churn	¼ H. P.	175			
Electropurification of milk	120-240 W. per quart			.01-.02 kwh per qt.	5 kwh per cow
Churn & butter worker	2 H. P.	1500			

C. POULTRY APPLICATIONS

	Installed Capacity	Demand Expected (watts)	Probable hrs. use per mo.	Ave. Cons while in operation	Monthly cons. kwh.
Oyster shell crusher (1000 hen farm)	½ H. P.	350	10	300 W.	3 kwh
Poultry Feed Mixer	3 H. P.	2500	4	2250 W.	9 kwh
Egg Tester	10 W.	10			
Brooder					
150 chick	277 W.	277	360		99 kwh
500 chick	463 W.	463	360		167 kwh

	Installed Capacity	*Demand Expected (watts)*	*Probable hrs. use per mo.*	*Ave. Cons while in operation*	*Monthly cons. kwh.*
Incubator					
150 egg	150 W.	150	200 per		30 kwh
500 egg	390 W.	390	200 hatch		78 kwh
Elec. Lighted Chicken House (1000 hen)	800 W.	800	94	800 W.	75 kwh
Feed Grinder	5 H. P.	4750			
Corn Sheller (2 hole)	1 H. P.	950	15	750 W.	11.3 kwh
Water Heater					
Grain Cracker (1000 hen farm)	½ H. P.	480	30	350 W.	10.5 kwh
Stimulation of fowl growth					

D. HORTICULTURAL APPLICATIONS

Small Fruit harvester	1/6 H. P.	100			
Cider Press	5 H. P.	3500			
Cider Mill	2 H. P.	1400			
Dehydrator	5 H. P.	3500			
Fruit Packer	¼ H. P.	170			
Spraying Apparatus	3 H. P.	2000			
Fruit Press					
Frost Prevention					
Destruction of insects					

E. RESIDENCE APPLICATIONS

Clothes Dryer, Centrifugal	1 H. P.	720	8	770 W.	6.2 kwh
Meat Chopper	½ H. P.	470		400 W.	
Bread Mixer					
Bell Ringing Transformer	10 W.	8			
Rectifier	50 W.	50	4	50 W.	.2 kwh
Curling Iron	20 W.	20	1	20 W.	.02kwh
Warming Pad	50 W.	50	25	50 W.	1.25kwh
Sewing Machine Motor	50 W.	50	8	50 W.	.4 kwh
Hair Dryer	300 W.	300	4	300 W.	1.2 kwh
Toaster	500 W.	500	6	500 W.	3 kwh
Grill	500 W.	500	6	500 W.	3 kwh
Flatiron	600 W.	600	10	600 W.	6 kwh
Percolator	400 W.	400	10	400 W.	4 kwh
Heater	600 W.	600	13	600 W.	8 kwh
Egg beater	15 W.	15	2	15 W.	.03kwh
Immersion beater	350 W.	350	2	350 W.	.7 kwh
Humidifier					
Ozonator					
Siren	100 W.	80	1	100 W.	.1 kwh
Wash. Machine	¼ H. P.	240	8	175 W.	1.4 kwh
Ranges	5000 W.	5000	50	2500 W.	125 kwh
Vacuum Cleaner	200 W.	150	10	200 W.	2.0 kwh
Fans	50 W.	50	26	50 W.	1.3 kwh
Elect. Phonograph	20 W.	20			
Waffle Iron	600 W.	600	4	600 W.	2.4 kwh
Refrigerator	¼ H. P.	200	250	200 W.	50 kwh
Piano, Electric	1/12 H. P.	60	15	60 W.	.9 kwh
Dishwasher	50 W.	50	15	40 W.	.6 kwh
Vibrator	50 W.	50	5		
Grinder & Buffer	250 W.	250	4	200 W.	.8 kwh
Soldering Iron	200 W.	200	2	200 W.	.4 kwh

	Installed Capacity	*Demand Expected (watts)*	*Probable hrs. use per mo.*	*Ave. Cons while in operation*	*Monthly cons. kwh.*
Portable Motor	¼ H. P.	240		200 W.	
Mangle					
Gas Heated	200 W.	200	12	200 W.	2.4 kwh
Elec. Heated	3000 W.	3000	12	3000 W.	36 kwh
Ice Cream Freezer	1/6 H. P.	150	4	100 W.	.4 kwh
House Lighting					
8 People Summer	440 W.	200			13.3 kwh
160 A. Winter	440 W.	200			24.9 kwh
6 People Summer	250 W.	100			3.4 kwh
80 A. Winter	260 W.	100			11.7 kwh

RELATION OF HIGHWAY LIGHTING TO RURAL ELECTRIFICATION

The lighting of highways bears an important relation to the question in hand since pole lines whose primary function is to carry circuits for highway lighting may also serve as main arteries whereby rural districts can be reached by means of extra wires on the same poles.

Figures which we have collated from a blue print map prepared by the State Highway Department in connection with a recent traffic count are as follows:

	Miles	Average Traffic per day Automobiles	Trucks
Primary Highway, Improved	2,475	1,421	171
Primary Highway, Unimproved	900	531	58
Secondary Highway, Improved	1,800	747	106
Secondary Highway, Unimproved	3,300	431	56

Cars and trucks going both ways were counted at 980 stations on week-days. The above figures are for year 1923 and should be increased about 20 per cent. to apply as of August, 1924.

There is no question that the economic advantages to be derived by illuminating all or a substantial part of these roads will greatly outweigh the cost of doing this. These advantages have been effectively set forth by Mr. K. V. Farmer as follows:

1. It prevents accidents:
   (a) By reducing headlight glare.
   (b) By illuminating dangerous curves.
   (c) By throwing light upon the signs at the sides of roads and upon obstacles.
2. It adds to the comfort of night driving:
   (a) By relieving eye strain.
   (b) By assisting in making repairs.
   (c) By discouraging hold-ups.
3. It increases night traffic and thereby relieves day congestion.
4. It decreases running time and increases road capacity.
5. It helps bring electricity to the farm by providing a pole line.

A 6th item may be added although it was not included in Mr. Farmer's

list, namely: On the 4,275 miles of improved highway in Pennsylvania there will probably be no less than 10,000 motor vehicles strung out at any moment during the early evening. If these highways were electric lighted, each vehicle would be able to save 32 watts by virtue of being able to run with 4 watt side lights in place of 20 watt headlights. In four hours the saving would be 1,280 kilowatt hours which at 35 cents per kilowatt hour, (a figure drawn from experience with farm lighting units) would amount to $448 per day. Nearly $500 per day could thus be credited against the cost of lighting the highways.

A 7th element is to be found in the greater safety which lighted streets afford. A survey made recently in thirty-two cities shows that from 17½ to 50 per cent of all automobile accidents are directly traceable to poor and insufficient street lighting.

Rural Electrification in Canada

The cost of electric power to the Municipal Corporation which operates the rural lines in Toronto Township is made up of elements illustrated by the following computation which is the Hydro Electric Commission's account with the same corporation beginning and ending one month earlier than the year we have had under consideration. For this reason the cost does not entirely agree.[1]

Cost of power to Hydro Electric Power Commission,	$4,844.93
Operating maintenance and administration expenses,	1,724.29
Interest,	1,011.55
Renewals,	269.36
Contingencies,	288.80
Sinking fund,	288.31
Total cost of power for one year as delivered to the Municipal Corporation by the Hydro Electric Power Commission	$8,427.24

The province of Ontario not only loans its credit as a basis for bond issues by means of which rural lines are largely financed but it also pays to a municipal corporation undertaking such a rural electrification one-half of the cost of primary lines. Toronto Township is, however, not typical in the last named characteristic and received no bonus as the lines described are comprehended within the so-called "voted area". The Commission operates the Streetsville rural power district which embraces that part of Toronto Township outside the voted area. Lines in this latter rural power district are bonused by the Provincial Government but have nothing whatever to do with lines of the foregoing statement.

The following table, VI, gives details of the operation of four electrified rural districts in the province of Ontario, all of which are served by the Hydro Electric Power Commission.

[1]In Technical Report No. 5 under "Rural Electrification in Canada," the cost of power purchased during the year ending December 31, 1922 was given as $8,862.66.

Table VI. Details of the Operation of Four Electrified Rural Districts in Ontario, Canada

		Average Number of kwh. per Consumer per Month		Average Amount Paid per kwh.	
		During Quarter ending July 31, 1923	During Quarter ending Jan. 31, 1924	During Quarter ending July 31, 1923	During Quarter endiing Jan. 31, 1924
Simcoe					
7	consumers	17.7	97.	30.7¢	8.2¢
.23	miles of line				
64	miles from Niagara				
30	consumers per mile				
Chatham					
138	consumers	48.8	76.2	12.6¢	7.62¢
24.25	miles of line				
160	miles from Niagara				
5.6	consumers per mile				
Ridetown					
89	consumers	27	49	18.3¢	11.6¢
25.75	miles of line				
145	miles from Niagara				
3.5	consumers per mile				
		June, 1923	Dec., 1923	June, 1923	Dec., 1923
Saltfleet					
465	consumers in June	49.5	62.1	8.1¢	7.¢
426	consumers in December				
59.9	miles of line				
40	miles from Niagara				
7.4	consumers per mile				

RURAL ELECTRIC LINES IN MISSOURI

The Union Electric Light and Power Company has published complete details covering the operation of six lines supplying rural service and several small farmer communities in St. Louis County, Missouri, for the twelve months ending November 30, 1922. These lines aggregated 20.35 miles in length and supplied 148 consumers.

Character of electrical equipment of the 148 consumers:

28 consumers had lighting and domestic appliances.
71 had range and lighting.
4 had motors and lighting.
5 had motors, range and lighting.

148

The average consumption was 103 2/3 kilowatt hours per month and the monthly bill $5.26 or at the average rate of a trifle over 5 cents per kilowatt hour.

The total investment in these lines was borne by the consumers and the company, the latter having paid 72.8 per cent. of the total cost, the company's share being $37,179.57. The operating revenues amounted to $9,345.37 and total operating expenses $7,193.31. The operating expenses include all conceivable items including cost of power at .543¢ per kilowatt hour as delivered to the line, depreciation at 6½% on the *combined* investments of the company and the consumers, lamp renewals, commercial and general expenses. The amount available as return on the money invested by the company is therefore $2,152.06 or 5.8 per cent.

RURAL ELECTRIC SERVICE IN CALIFORNIA

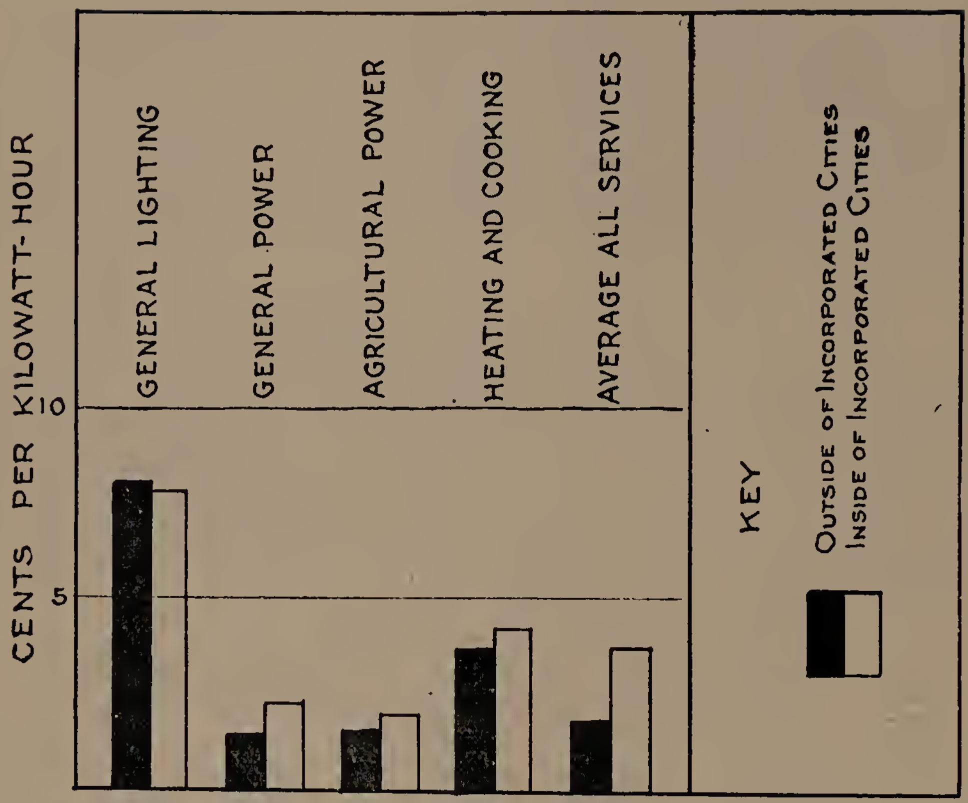
The Santa Anna District, which is served by the Southern California Edison Company, lies about 35 miles southeast of the City of Los Angeles as measured from center to center. The district is in the shape of a rhombus measuring about 20 miles on a side and having two of its sides lying east to west and the other two northwest to southeast. In 1920 this district contained a population of 46,114 of which 29,171 were in 6 small cities and the remainder in essentially rural districts. Pumps, used for irrigation, consume by far the largest amount of energy of any one class of service in the district. There are in the Santa Anna District:

267 miles of 10,000 volt distribution lines
100 miles of 2,300 volt primary lines
200 miles of 100 and 220 secondary lines
165 miles of street light wire

The following table gives the various features of operation in the Santa Anna District for the month of August, 1923, so stated as to place in comparison the conditions which obtain in rural and urban areas. It is clearly evident from these figures that the rural districts are called upon to pay no more for service than the cities for the same service.

Table VII. Statement of Rural and Urban Service in Santa Anna District, California

Outside of Incorporated Cities	Inside of Incorporated Cities	No. of Consumers	Kilowatt hours consumed	Revenue obtained	Kwh. used per consumer	Revenue per consumer	Revenue per kwh.
General Lighting		3,388	130,239	$10,488	38.4	$3.09	8¢
	Gen. Lighting .	11,451	360,173	$28,111	31.4	$2.45	7.8¢
General Power		103	368,481	$5,315	3,577	$61.6	1.4¢
	Gen. Power ..	353	405,160	$9,004	1,148	$25.50	2.2¢
Agricultural Power		477	2,597,706	$41,613	5,445	$87.24	1.6¢
	Agricultural Power	71	166,303	$3,389	2,342	$47.7	2¢
Heating and Cooking		221	43,051	$1,607	195	$7.27	3.7¢
	Heating and Cooking	39	4,967	$208	127	$5.33	4.2¢
All services		4,195	3,148,516	$59,495	750	$14.18	1.9¢
	All services ..	11,943	1,271,856	$47,072	106	$3.94	3.7¢
All services		16,138	4,420,372	$106,567	274	$6.60	2.4¢



AVERAGE COSTS PER KILOWATT-HOUR TO CONSUMERS IN THE SANTA ANNA DISTRICT IN CALIFORNIA SERVED BY THE SOUTHERN CALIFORNIA EDISON CO.

Rural Load Factors—A load factor is the ratio of the average rate at which electric energy is used to the maximum rate, or so-called "Demand," for some definite period as an hour, a day, a month or a year. The load factor for a short period, as for a day, will usually be greater for the same system, than if taken for a longer period as a year. A low load factor has been the bug bear that caused a utility to stop, look and listen before engaging to provide service to a line burdened with such a characteristic. A purely electric lighting load, extending as it does over but a few hours of the day and night produces by itself a low load factor. The use of motors or any electrical appliance at other than lighting hours will ordinarily improve the load factor. However, a very large motor such as used for threshing employed as it is only a few days in the year will not only increase the "Demand" but will lower the yearly load factor thereby. Increasing the demand is in itself one of the deadly sins in the decalogue of a utility unless the load factor can be increased also. Both effects, decreasing load factor and increasing demand

put extra investment burdens on the utility without causing a sufficient increase in revenue to compensate. This is reflected in the rates. The ideal consumer would use electricity at a uniform rate at all hours day and night. In such a case the consumer's load factor would be 100 per cent. and his demand no greater than his average consumption. Under these conditions electric energy could be sold at a very low rate indeed. To accomplish such a state of affairs certain utilities in England have developed a method in which current is delivered at a constant rate and a switch is provided whereby a member of the household may switch it from one set of devices to another but is unable to cut off or lessen the supply. When the current is not needed for lighting and cooking it can be switched on to the electric iron and water heater, or it can all be delivered to the water heater.

Load factors actually observed on certain rural lines are as follows:

Rural Communities on the Minidoka Project, a Government Irrigation Enterprise in Idaho.

During the year 1919

Miles of distribution lines	196 miles
Number of consumers	731
Annual load factor	18.4 per cent.
Average monthly load factor	24.4 per cent.
Average consumption per month per consumer	58 kwh.

The Rural Lines Committee of the Wisconsin Electric Light Association.

Reported 1923

An extension having 82 consumers engaged in dairying and hay raising.

Number of consumers	82

Connected Load

Electric irons	33,855 watts
Hot plates	9,000 watts
Stoves	6,000 watts
Power	95,488 watts
Light	94,345 watts
Total	238,688 watts
Maximum load on day of test	28.8
Daily load factor for day of test figured from readings of recording meter	37.6%

If the primary circuit of the transformer serving a farm were to remain open when no current is required in the manner soon to be described, both the load factor and average power factor would be very materially improved.

Rural Power Factors—The practice of using alternating current to electrify rural lines is universal. Such a current has the peculiarity that not all of the electric energy which it carries out on the line to the consumer's premises is delivered and left to do useful work. Electric motors in particular cause a part of the energy which reaches them to return on the line to the point where it was generated. This useless wash of a part of the electric

energy back and forth in the line without doing anyone any good makes it necessary to use much larger and more expensive generating and transmitting equipment than would otherwise be necessary. The proportion of the energy that stays put after it has reached the consumer's premises to the total apparent energy which is received is known as the power factor of the consumer's load. It is analogous to the measure of the usable energy which would be delivered to the train by the heavy drive wheels of a locomotive as a percentage of the energy delivered by the steam to the piston if the piston rod were made of rubber instead of steel. In such a case much of the energy of the steam would be used in compressing the rubber. It is true the rubber would expand and help start the piston at every reversal of its motion but a much larger and more powerful engine would be required than if no elastic medium intervened. The power factor may vary greatly during the day and night. When no electricity is being taken from a transformer its power factor is especially low. If the device were cut out of circuit at such times the average power factor of the consumer's load would be much improved. Whether specifically so stated or not rates are always higher than would be the case were it possible to count on a 100 per cent. power factor for the consumer's load. A 100% power factor can be maintained in any installation by the use of so-called static or rotary condensers and under certain conditions it will pay to adopt them. However much can be done to insure a high power factor by merely choosing suitable equipment. The following precautions are important in this connection.

The transformer should be as small as possible while yet being large enough to carry the maximum load that the consumer is likely to place upon it.

Motors should be as small as will properly accomplish the work required of them.

A motor should be chosen which has an inherently high power factor. A single phase motor with a power factor between .9 and .95 at full load has recently been developed and is being placed on the market. The use of such motors will go far toward overcoming low power factor conditions.

The Rural Lines Committee of the Wisconsin Electric Light Association has reported hourly power factors observed in two rural extensions as follows:

Extension E

Length of line in miles	5.5
Number of consumers	16
Minimum power factor. Occurred at 12:30 A. M.	19.1%
Maximum power factor. Occurred at 7:05 P. M.	55.5%
Average power factor 1:00 P. M. to 12:30 A. M.	33.9%

Extension C

Length of line in miles	24
Number of consumers	47
Minimum power factor. Occurred at 1:50 P. M.	28%
Maximum power factor. Occurred at 7:00 P. M.	85.5%

A low power factor can be perfectly or partly corrected by the use of electrostatic condensers according to whether conditions will warrant the purchase of a sufficiently large condenser or only a smaller one. Take for example, a 5 H. P. motor operating at half load. It may under these conditions have a power factor of only 55 per cent. If a condenser of 2.27 K. V. A. be installed the power factor will thereby be brought up to 90 per cent. at a cost of about $136 for the condenser. Whether a farmer could afford to install such a condenser would depend on how much reduction in the rate charged for service the utility serving him would make in order to secure the improved power factor. Messrs. LaCour and Holmgren, writing on the Power Factor Problem in Sweden state: "The problem in Sweden is most acute in rural districts * * *. It is the opinion of the Swedish engineers making these studies that 35% of the cost of transformer installations and the same proportion of the energy losses could be saved by power factor correction. * * * Calculation made on a typical circuit showed that it would be worth while for the farmer to spend 30% more for his motors if thereby he could secure approximately unity power factor and that the resulting saving in the yearly cost of power would be at least 20% * * *."

Opening of Primary Circuit of Transformer when No Service is Required—Frequently as much energy goes to waste in merely heating up the transformer through the course of the day and night as is used by the consumer during lighting hours or when he is using power. The rate at which this loss, known as iron loss, goes on is independent of whether current is being used or not. Opening the primary circuit of the transformer during the many hours when current is not wanted by the consumer would therefore save the waste of a great amount of energy for which the consumer has otherwise to pay. Suitable devices for the purpose have not as yet been developed but that these can be effectively designed and applied is the firm belief of the writer.

One method of accomplishing the desired end is suggested by means of the accompanying diagram, which is here advanced more as a convenient method of stating the problem than as a complete practical solution.

In this diagram the various devices are designated by letters as follows:

W and V are the primary leads which deliver current at from 2,300 to 5,000 volts.

P is the primary and S the secondary circuit of the transformer from which current for light and power is drawn.

C is a static condenser of ¼ K. V. A. or more capacity.

L is the primary and M the secondary circuit of a very small transformer insulated for primary voltage of the circuit but having both windings of low voltage and low voltage ratio between them. The only function of this transformer is to energize solenoid K which alternately opens or closes a single pole primary switch J, when switch P is closed momentarily by the consumer. Switch J could be built on the ratchet principle like a chain pull switch used on lamp sockets but with suitable size, strength, and arc rupturing capabilities.

G is a common ground for the secondary circuit of both transformers.

R is the main switch in the consumer's premises and Q is a multi-position switch of peculiar construction. Switch R is to be opened only in case of emergency and may if desired be closed under seal by the utility representative. Q is so connected that it cannot interrupt the circuit in any position. It can only select a circuit to energize such as U, T or W, one alone or any combination as provided in the original hookup.

Circuits U, W and T are permanently attached, without the intervention of further switches or key sockets, to a few lamps, a pump motor or a water heater. The idea is to so arrange things that a certain small amount of electric energy will continue to be drawn from the secondary circuit so long as switch J is closed. The fact that the consumer's bill will be continually mounting slowly unless he closes switch P for a moment, thus causing J to open, whenever his need for current is at an end, will cause him to attend to the matter vigorously. When he wants current he has only to again touch P which is so constructed as to retract into the open position when pressure is removed.

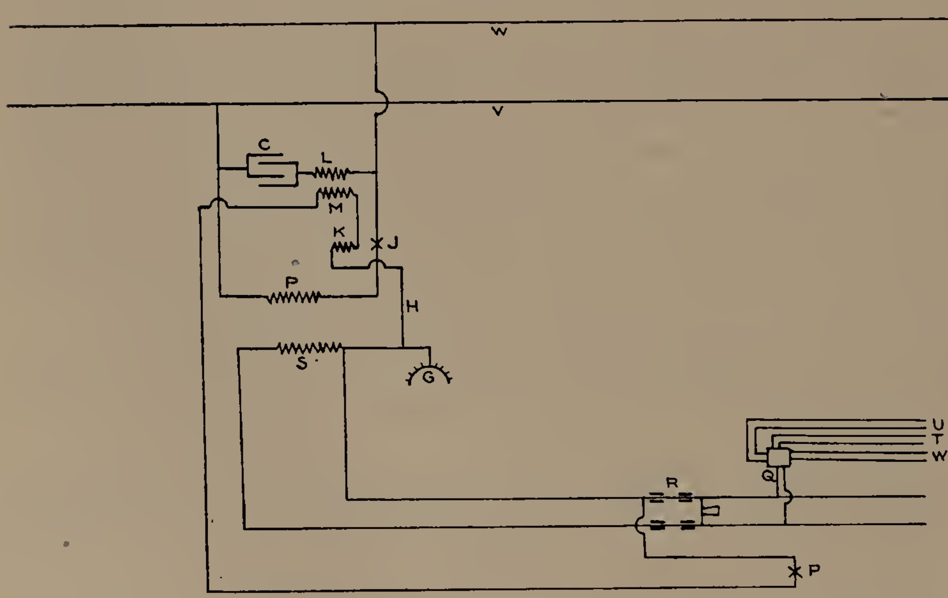


FIG. 2. SCHEME FOR OPENING TRANSFORMER, PRIMARY CIRCUIT

The capacity C, if no larger than ¼ K. V. A. will not go far toward improving the power factor under conditions of load but will greatly improve it for light load as when the secondary circuit is nearly idle or the primary open. In the latter case it would improve the notoriously bad power factor of the line during the day when not much electricity is flowing in it.

Meter Reading by the Consumer—Due to the great distance involved much time and expense is entailed by reading meters monthly in rural districts. This difficulty is overcome in some places by providing the consumers

with post cards having the meter dials printed on one side with the injunction "Please mark exact location of hands." A card is marked by the consumer at the end of each month to agree with the hands on his meter, and the card mailed to the utility office.

Use of Electric Range—There is no other device so capable of making rural electrification possible as the electric range. Whenever the Giant Power Survey has found a farm line successful from the standpoints of both the farmer and the utility, it has also found a goodly number of electric ranges being used. In Waukesha County in Wisconsin out of 82 farmers who replied to questionnaires 41 were using electric ranges.

Tests on combined lighting and range loads reported in the General Electric Review of August, 1922, show that such loads are desirable from the view point of the central station as well as that of the consumer. The article referred to states "It is evident that the addition of a range load very considerably smoothes out the residence district load curve and makes use of distribution facilities otherwise practically idle during the day. During the winter the range and lighting peaks overlap somewhat; during the summer there is almost no overlap. A number of central stations have made tests to determine the relation of connected load to station capacity for ranges. It has been generally agreed that this ratio is approximately ten to one, that is, but 600 watts of station capacity is required to service a 6,000 watt range."

NOTES ON RURAL PRACTICE IN SWEDEN

Protective Equipment Abandoned in Sweden—W. Borgquist of Sweden, pointed out that Sweden found it necessary to build cheaply in order to save money, and that this has proved to its advantage. The plant was made simple, the amount of protection reduced to a minimum, single lines on wooden poles were used, and in every case, the mechanical strength was accommodated to the economic importance of the structure under consideration. During the last ten years the Swedes have abandoned lightning arresters, choke coils, etc., and there has been no trouble; on the contrary, the system has worked better.—*National Electric Light Association Bulletin*, September, 1924. Vol. XI, page 536.

Electricity in Agriculture—Mr. Holmgren, also of Sweden, pointed to the opportunity of unity-power-factor motors to replace the usual induction motors, on farms particularly. Two things are accomplished—(a) much better regulation, but, more important, (b) a great reduction in transformer sizes. He felt a 30 per cent. higher cost and a 5 per cent. lower efficiency in the unity-power-factor motor as compared with the induction motor will still save 25 per cent. of the cost of power delivered on account of the reduction of losses.—*National Electric Light Association Bulletin*, September, 1924. Vol. XI, page 538.

THE FIELD FOR RURAL ELECTRIFICATION IN PENNSYLVANIA

Conclusions advanced in the main body of this report as to the extent and character of the various townships in regard to their suitability for

rural electrification rest upon two extensive studies. Each study was carried out by a representative of the Giant Power Survey aud consumed several months.

Mr. Otto Rau ascertained and plotted the areas which are at present served from distribution lines as distinguished from transmission lines.

Mr. Perry R. Taylor found the number of farms per mile of road in each township, the area of the township, the number of farms having twenty or more animal units, (one animal unit consists of one mature horse or cow, 6 hogs, 8 sheep, or 100 chickens—young stock to be counted as half as much as mature animals) the farm population and non-farm population outside of incorporated places. In the prosecution of this work Mr. Taylor received valuable assistance from the State Highway Department, Department of Agriculture aud from County Commissioners. As the result of some of his investigations Mr. Taylor was able to prepare the accompanyiug map (Fig. 3).

In the map herewith presented the cross lines represent average road conditions throughout the State. Each county has been taken as a unit for averaging purposes. The mesh in each case represents to scale the average distances between cross roads. To facilitate graphical representation the roads have been straightened, laid at right angles to each other, and spaced evenly. Due to the small scale of the map it was necessary to adopt an arbitrary scale by means of which to represent the distances between cross roads, namely thirty-six thousandths of an inch equal to one mile. The scale of the map itself is twenty-three thousandths of an inch to the mile. There are therefore many more road intersections in each county than appear on the map as drawn. Figures shown in the circles represent, respectively, the average number of farms per mile of road in the counties in which they are found.

Mr. Taylor's figures have developed the fact that the population of the State was distributed very nearly as follows, as of the year 1920.

Population of cities and other incorporated places—exclusive of Philadelphia;	4,259,544
Population of unincorporated places not on farms	1,706,756
Farm population	822,266
Total (exclusive of Philadelphia)	6,788,566

DISTRIBUTION OF SERVED AND UNSERVED TOWNSHIPS

734 Townships. Nearest electrified points from centers of townships are at an average distance of 5.77 miles. These points are in distribution lines serving two or more towns or districts.

132 Townships. Nearest electrified points from centers of townships are at an average distance of 4.87 miles. These points are in distribution systems of public or private plants serviug single towns. 61 of these 132 townships are within an average distance of 10.4 miles of distribution lines serving two or more towns or districts.

All remaining townships. Each township is served in whole or in

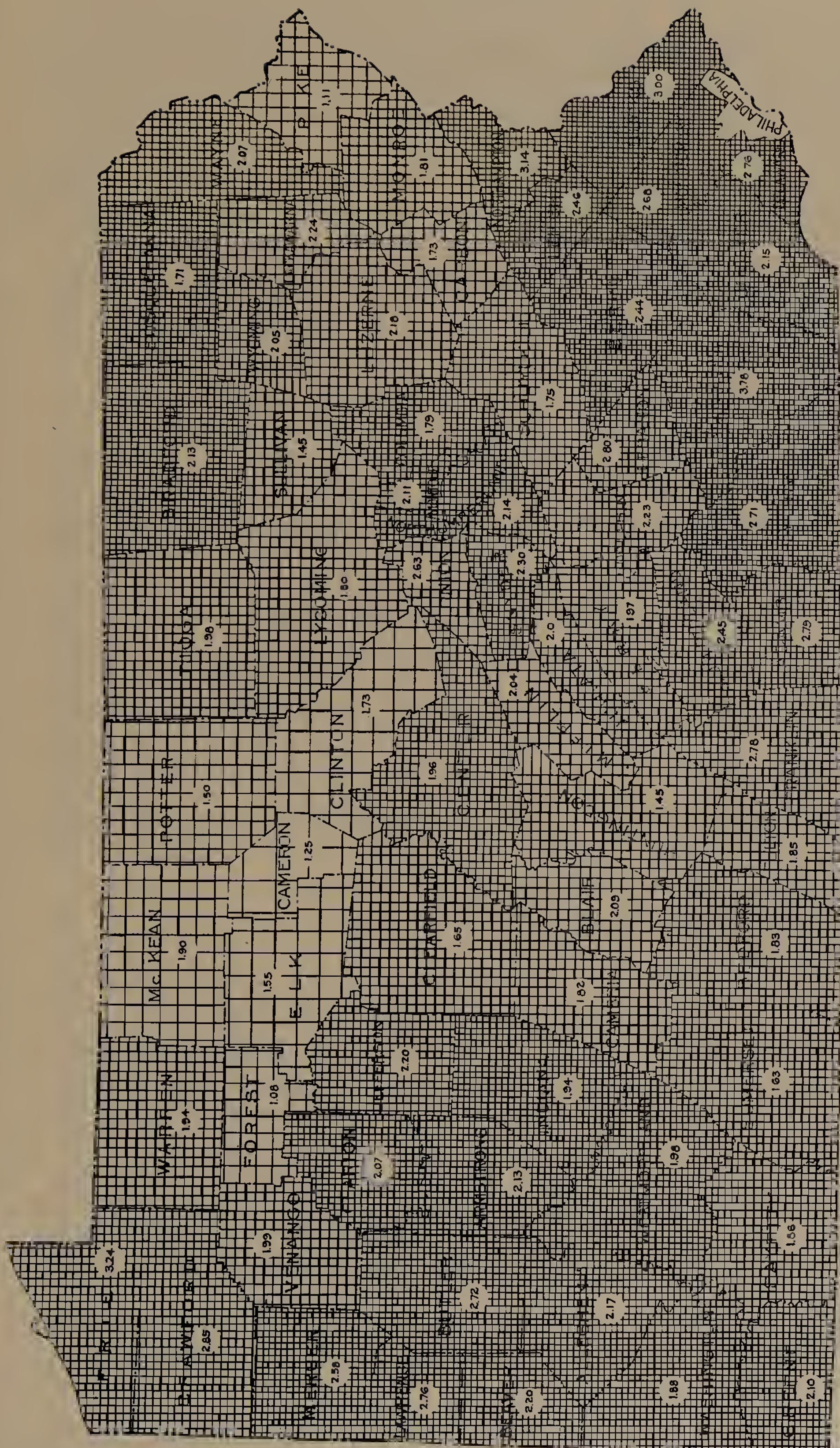


FIG. 3. MAP SHOWING RELATIVE DISTANCES BETWEEN CROSS ROADS AND THE NUMBER OF FARMS PER MILE OF ROAD

The spacings between the cross lines represent the average distances between roads in each county. The numerals show the farms per mile of road in each county.

part. 25 per cent of the aggregate area covered by them is thus served. There are approximately 700 of these townships.

Table XIII. Details of Disposition of Classes of Consumers with Increasing Mileage of New Line

Section of Pole Line Considered	Population Served Includes farm and non-farm population not in incorporated places	Percent of Population Served by Section of Pole Line Named, Which Lives in Townships in Which the Number of Farms per Mile is:—			
		Above 3½	3 to 3½	2½ to 3	2 to 2½
0 to 837 Miles Distance of center of township from nearest electrified point.	35,865	100% 0 to 1 Mile			
837 to 3,185 Miles	107,124		100% 0 to 1 Mile		
3,185 to 3,621 Miles	14,016		100% 0 to 2 Miles		
3,621 to 10,013 Miles	304,950	1.28% 2 to 4 Miles	13.12% 2 to 4 Miles	39.3% 0 to 1 Mile	46.3% 0 to 1 Mile
10,013 to 13,142 Miles	94,659	15.9% 4 to 8 Miles	39.4% 4 to 8 Miles	22.7% 0 to 2 Miles	22% 0 to 2 Miles
13,142 to 13,760	12,159	7.7% 8 to 14 Miles	92.3 8 to 14 Miles		
13,760 to 17,697	100,659			36.3% 2 to 8 Miles	63.7% 2 to 8 Miles
17,697 to 18,790	17,838			18% 8 to 12 Miles	82% 8 to 21 Miles
18,790 is 42% of length of pole line required, namely 44,788 miles, to reach an unserved population of 1,399,274 which is nearly ¾ of the unserved population of the State.	Total 687,270. This is 49% of the unserved population that can be reached by building 44,788 miles of pole line.	All partially served and unserved townships having 2 or more farms per mile are provided for in the above table.			

RURAL ELECTRIFICATION IN FOREIGN COUNTRIES

The Department of Commerce, has recently issued, through its Bureau of Foreign and Domestic Commerce, several special circulars from which the following excerpts have been taken, a few comments being added by the present writer.

Special Circular No. 311, Rural Electrification in German States—"The ownership of electric power plants in Germany is equally divided between the Government and private interests. Some Provinces also own and operate electric generating plants, an example being that of the Province of Pomerania in East Prussia."

"There are numerous power cooperatives in Germany that buy electric energy in bulk and distribute it to the members of the association within the area served by them."

Special Circular No. 308, Rural Electrification in the Netherlands—"It is estimated that electricity is at present readily available to the farmers in about 50 per cent. of the agricultural area."

"At present there is a strong tendency to leave the production of electric current entirely to the State, whose various commissions have, during recent years, been working out plans and schemes whereby the whole country would be covered by a net work of high tension wires, fed with current at a few points."

"The outlines of the scheme were that the State would generate the current and transmit it at high tension to the various distribution centers. and then each Province would take the necessary steps to facilitate the further distribution of electricity."

Special Circular No. 307, Rural Electrification in Sweden—"It has been definitely decided by Swedish Government officials that in its further development of electric power, the State will give due consideration to the needs of agriculture which it is estimated, will consume about 390,000,000 kilowatt hours per annum, their present power consumption being approximately 30 per cent. of this amount."

Special Circular No. 301, Rural Electrification in France—It appears from this circular that the larger plants in France provide current for only about 6,000 of the 36,000 communes in that country. The circular states further. "The authorities consider that power can be economically distributed to 20,000 additional communes having a total population of 10,000,000 practically all of which can be classed as rural." This program is said, in the circular, to be assured of obtaining considerable progress by means of the law of August 4, 1923, which makes provision for the granting of special loans for the extension of electrical service in France. A summary of the provisions of this Act is as follows:

"The State may place at the disposition of the National Office of Agriculture Credit, funds to permit this establishment to grant special loans to departments, syndicates of communes, communes, economic groups, and co-operative societies. These loans must be for establishing rural electrical service and can not be for a period longer than 40 years."

"Electric power, in the few instances in which it has been employed for plowing has been successful. It is claimed that electricity permits deeper plowing and will result in increasing the amount of crops produced by 20 per cent."

Special Circular No. 297, Rural Electrification in New Zealand—"The Dominion Government has schemes projected for the supply of the entire country by means of hydro-electric power, the present basis of estimated consumption being .2 hersepower per head of population."

"The chief uses of electricity in the farms are roughly, in order of importance as follows:

Milling, hot water supply, lighting, heating, cooking, pumping water, sheep shearing, cream separating, etc."

"The power boards and local authorities assist individual farmers by advancing money to install wiring and motors as well as cooking and heating appliances."

"Approximately 35 per cent. of the agricultural districts have electric power available."

Special Circular No. 300, Rural Electrification in Italy—"It is in Northern Italy, where the water supply is more plentiful, that the greatest progress has been made. A network of transmission lines exists and, furthermore, the availability of electric energy is greater during the summer months when agricultural activity is also greatest. Thus, in this section of the country, there are at present many applications of electricity to farm uses, including the pumping of water, plowing, harrowing, threshing, fodder cutting, and many other operations."

"Those who have studied the problem in Italy most carefully have concluded that an intermediary (as between companies generating current and the farmers) is necessary. The demand for electric power in Italy still exceeds the available supply and while this condition continues the power companies have no need to intensify their efforts in the matter of attracting new consumers." A few intermediary organizations of the type referred to in the circular are said, therein, to be already in the field, the most important being the Societa Cooperative Italiana Agricoltori Meccanici Elettricisti, which is operating in the Roman Campagna, and the Anonima per l'Elettro-Agricoltura of Bologna. Membership in the first named society is open to all farmers, mechanics and electricians who are capable of carrying out or directing its activities. Members are required to pay an entrance fee and at the same time to purchase stock, with par value of 100 lire per share up to a maximum of 5000 lire. The stockholders receive 70 per cent. of the net profits until they have received 6 per cent. dividends and the balance goes to the members and all other employees on the basis of the salaries received.

The Anonima per Elettro-Agricoltura, is stated to have carried out the following operations in 1923:

Plowing	17,544.1	acres
Harrowing	494.2	acres
Threshing rice	3,706	tons
Drying rice	1,629	tons
Pumping water	1,500	kwh.
Other operations	30,000	kwh.

In October 1919 the Government offered substantial annual subsidies to run for a period of 15 years for erection and operation of hydro electric plants and for both industrial and agricultural electric lines. These subsidies are partly based upon installed equipment and partly upon electric energy supplied and consumed for agricultural purposes.

V. CURRENT RATE MAKING FOR RURAL ELECTRIC SERVICE

BY GEORGE H. MORSE

Type of Rural Rate Considered: Rates for rural service may be divided into two classes, namely, those which arrive at the amount to be paid by the consumer by adding something to the established rate for domestic service in the town or city from which the line eminates, and those in which the amount of the bill is figured independently of urban rates by computing the proper proportion of all costs involved in reaching and serving the rural consumer.

The former or city-plus rate has not been found in use in the several localities in this and other states, where the Survey has found rural electrification successfully carried on from the standpoints of both consumer and producer. A rate which considers only those elements of producing rural service which can be directly assigned to this class of service irrespective of any equitable or inequitable rates which may be in force in neighboring cities appears to be the most logical. For these reasons we will hereinafter consider only the last mentioned or independent sort of rates.

Theoretical Cost Curves: In order to have a datum line, so to speak, a standard of reference, the elements in the composition of which are clearly known, we have developed curves for the cost of rural service based upon the method advanced by Mr. W. J. Greene in the *Electrical World* for September 23, 1922. The data therein adopted by Mr. Greene has been used with the exception that, $1.20 allowed by Mr. Greene as a monthly power plant and transmission "Demand" cost per consumer, was excluded. It should also be stated that we have extended the computations to cover monthly consumptions of energy much in excess of those employed by Mr. Greene and such as he might consider inconsistent with the average "Demand" which he assumed. Aside from any conclusions as to the equity or practicability of the results expressed by these curves they offer a means of locating, relatively to one another, the various factual curves exhibited and may be taken to represent in their general trend, the sort of curves which an exhaustive study of the subject is likely to produce.

Fig. 1 exhibits in theoretical curves A-1_3, B-1_3 and C-1_3 the cost to the consumer in cents per kilowatt hour delivered per month for various monthly consumptions when there are three consumers per mile of line and for the three following conditions as to financing of the line as assumed by Mr. Greene.

Curve A-1_3 The consumers own and maintain the rural line and equipment. No provision is made for rebuilding the line at the expiration of its natural life taken as fifteen years.

Curve B-1_3 Consumers finance the line. The utility owns, maintains, operates and reconstructs it at its own expense.

Curve C-1_3 The utility constructs and owns the rural line and maintains and operates it as for urban service.

The curves have been computed by a method which makes an allowance

for fixed charges on all investments made by the utility in the rural extension and its equipment including eight per cent. as return on these investments. Meter shunt losses, transformer core losses, commercial office and general expenses have also been provided for. The energy rate is taken at three cents per kilowatt hour to the consumer.

It is interesting to compare these theoretical curves with others derived from actual practice.

Rates in Ontario, Canada—Curves J, J-1, and J-2, Fig. 1, represent the average values derived from three rural lines in the Province of Ontario, namely—those known as the Chatham, Ridgetown and Saltfeet rural lines, the particulars concerning which are given on another page of this report. These lines are operated at cost, pay no taxes and obtain money for their financing on a basis comparable with that by which governmental funds are obtained. These lines derive ample revenue from the sale of current on the average basis expressed by these curves and the rates are undergoing a slow process of reduction.

It should be noted that the curves we have used to illustrate the Ontario rates are each based on but two known points which have been indicated by small circles. Away from these points the curves are more or less conjectural.

The Minnesota Experiment. The experimental work being carried on at Red Wing, Minnesota, offers a very good example of a rate structure which is independent of urban rates. It is set forth in Table XI and is self explanatory. One feature of the rate which has met with critical examination by the engineers of the Giant Power Survey is the magnitude of the initial energy charge, namely—5 cents per kilowatt hour. It is not clear to these engineers what the 2 cents in excess of the secondary energy rate, namely 3 cents per kilowatt hour, is intended to cover since all fixed charges have apparently been previously taken care of. Appeal to the makers of this rate did not elicit a satisfactory explanation. Curve K, Fig. 3, represents the Minnesota rate paid by the consumer when he has financed his proportion of the cost of the extension as prorated amongst the consumers while Curve K-1 represents the rate paid when the utility does the financing.

Table XI. Minnesota Experiment at Red Wing, Minnesota. Rural Charges Based on 5 Miles of Line 3 Customers to the Mile or 15 Customers, with 3 kw. of Demand per Customer. The Annual Revenue Diversity Factor 6 to 1

Table No. 1

Investment Items (Not including service from road to meter)

Item	*Description*	*Cost*
1.	7½ kw. of Station and Transmission capacity @ $250.00	$1875.00
2.	5 Miles of Line @ $850.00	4250.00
3.	5 3-kw. Transformers @ $75.00 each	375.00
4.	2 5-kw. @ $105.00	210.00
5.	15 Meters @ $10.00 each	150.00
	Total	$6860.00

Table No. 2

Fixed Expense Items

a.	Insurance, Depreciation, Maintenance and Taxes	7½%
b.	Interest, ...	8 %
c.	Trouble work, meter reading, etc. per customer per month	75¢
d.	Core losses per month per customer	25¢

Table No. 3

Fixed Charges Farmer Pays

Case A—Farmer Finances Line and Turns it over to Company

Items Entering	*Description*	*Total Annual Charge*	*Monthly Charge per customer*
1, a and b	15½% of $1875.00..............	$290.63	$1.61
2, a and b	7½% of $4250.00..............	318.75	1.77
3, and a	7½% of $375.00..............	28.13	.16
4, and a	7½% of $210.00..............	15.75	.09
5, a and b	15½% of $150.00..............	23.25	.13
c,			.75
d,			.25
Total	....		$4.76

Table No. 4

Case B—Company Finances Line

1, a and b	15½% of $1875.00..............	$290.63	$1.61
2, a and b	15½% of $4250.00..............	658.75	3.66
3. a and b	15½% of $375.00..............	58.13	.32
4, a and b	15½% of $210.00..............	32.55	.18
5, a and b	15½% of $150.00..............	23.25	.13
c.			.75
d.			.25
Total	....		$6.90

Rate

Case A. $4.76 for first 3 kw. or less per month
$.66 for each additional kw. per month.
First 30 kw. per month at 5¢ per kwh.
Excess kwh. per month at 3¢ per kwh.

Case B. $6.90 for first 3 kw. or less per month.
$.78 for each additional kw. per month.
First 30 kwh. per month at 5¢ per kwh.
Excess kwh. per month at 3¢ per kwh.

Prof. E. A. Stewart has recently reported that the average consumption per consumer has reached 200 kwh. per month on the Red Wing experimental lines.

Rates in Pennsylvania—There are in Pennsylvania 17 public utilities which have filed specifically "Rural Rates" with the Public Service Commis-

sion. The effect of these rates is to produce the following average costs per kilowatt hour to the consumer:

50 kwh. per month	14.0 cents
100 kwh. per month	14.6 cents

We have elsewhere given the results obtained from 80 questionnaires which were returned by farmers living in various counties of the State which showed that they are using an average of 104.2 kwh. per month for which they pay 8.2 cents per kilowatt hour. Curve L, Fig. 1, represents the effect of the average values of the published rates to domestic consumers in 10 Pennsylvania cities which range from 9,000 to 24,000 inhabitants. It is to be noted that the above figures, namely 104.2 kilowatt hours at 8.2 cents per kilowatt hour indicate a point shown on the diagram which lies close to the curve L.

Rates in Wisconsin—Curves G, G1, and G2, Fig. 2, represent the effects of the rural rates established by the Milwaukee Electric Railway and Light Company in October 25, 1920 and which are still in use to the satisfaction of both the company and its rural consumers. This is the most notable rural rate in regard to its simplicity and the satisfactory results which have attended its use which has so far been discovered by the Giant Power Survey. It comprises a service charge of $2.00 per month for four or less active rooms plus forty cents per month for each active room in excess of the first four. The service charge entitles the consumer to five kilowatt hours per month per active room. All energy in excess of this allowance is obtained by the consumer at 3½ cents per kilowatt hour. Lighting, cooking and motor service up to three horse power is done on this rate. Upwards of 200 rural consumers are served in Waukesha County, Wisconsin, at the last described rate. The utility expends two years estimated revenue toward the rural extension and the farmers furnish the remainder of the cost. It should be noted that the theoretical curve $B\text{-}1_3$ of Fig. 1, also appears in Figs. 2 and 3. The basis as to financing and so called "Demand" of curve $B\text{-}1_3$ is similar to that to which curve G-1 applies and comparison of these two curves, one with the other, shows that rates based on the theoretical curve would be considerably higher than those asked by the Milwaukee Electric Railway and Light Company for like rural service. The returns from questionnaires which were answered by Waukesha County farmers showed that during the winter months the average consumption of these farms, omitting the three largest users, is 107 kilowatt hours which is obtained at 5.2 cents per kilowatt hour. This point is indicated on the diagram and is found to lie on curve G-1.

The most interesting curve we have to offer is Curve H, Fig. 2. This curve was plotted from 10 points each indicated by a small circle as shown. 7 points were derived from the average monthly consumption per rural consumer for rural lines of 7 different Wisconsin utilities and the three remaining points represent three large and distinct rural divisions of an eighth Wisconsin company. The Milwaukee Electric Railway and Light Company and two of its associated companies are numbered among the eight utilities. This curve illustrates in a remarkable manner the economic and psychological

reactions of farmers as a class toward rates for electric service. As shown by the curve a given rate causes the farmer to accept and use a definite amount of electric energy. This curve approaches and even intersects the other curves of the diagram as it rises, a fact which suggests that a bold and liberal policy as regards the lowering of rural rates on the part of a utility will often be rewarded by sufficient increase of patronage to afford a liberal profit from such policy. All small circles in Fig. 2, except one indicated by the arrow, are associated with curve H.

Rates in Ontario.—Rates established in rural power districts in Ontario, served by the Hydro-Electric Power Commission are divided into seven major classes and several sub-classes based upon the probable magnitude of the "Demand," or maximum power that is likely to be drawn from the line at any time. As an example, the following classes, with their demand ratings and estimated annual service charges are given as applied to the Saltfleet Rural Power District. It should be noted that a reduction of 20% has recently been made in the annual service charge below that given in our table.

Table XII

Class	*Names*	*Demand Rating H. P.*	*Estimated Annual Service Charge*
I	Hamlet service (a)	2/3	$21.31
	(b)	1	25.90
	(c)	2 2/3	74.84
II	House lighting	1 1/3	36.29
III	Light farm service	4	78.10
IV	Medium single phase farm service	6 2/3	97.18
V	Medium 3-phase farm service	6 2/3	114.74
VI	Heavy farm service	12	190.61
VII	Special farm service	20	299.06

In addition to the service charge there is in the district under consideration energy charge as follows:

4 cents per kilowatt hour for the first 14 hours use per month of customers class demand rating;

2 cents per kilowatt hour for all remaining uses.

As an example, a consumer whose class Demand Rating is that of VI, Heavy Farm Service, if he uses 300 kilowatt hours during the month will be called to pay for it as follows:

14 hours use at 12 horse power (9 kilowatt) is 126 kilowatt hours which at 4 cents is $5.04;

The remaining 174 kilowatt hours at 2 cents is $3.48.

The sum of these energy charges is $8.52 and this is subject to 10% discount making the net monthly energy charge $7.67.

To the energy charge should be added one-twelfth of $190.61, the Estimated Annual Service Charge less the recent 20% reduction in this item. This amounts to $12.70.

The net amount paid for the use of this 300 kilowatt hours is therefore the sum of $7.67 and $12.70. This amounts to $20.37 or a cost of 6.8 cents per kilowatt hour to the consumer.

Rates in Sweden—Rates to the individual rural consumers in Sweden, according to the *Electrical World*, issue of May 17, 1924, vary between the extremes of a flat rate of 16 cents per kilowatt hour and a pure so-much-per-lamp-a-year or so-much-per-hectare rate. The majority of the societies are, however, said to have found it advantageous to use mixed tariffs, with an energy rate of only 2.67 cents per kilowatt hour. The fixed yearly charges then average 90 cents to $1.10 per acre.

COST OF ELECTRIC SERVICE TO RURAL CONSUMERS

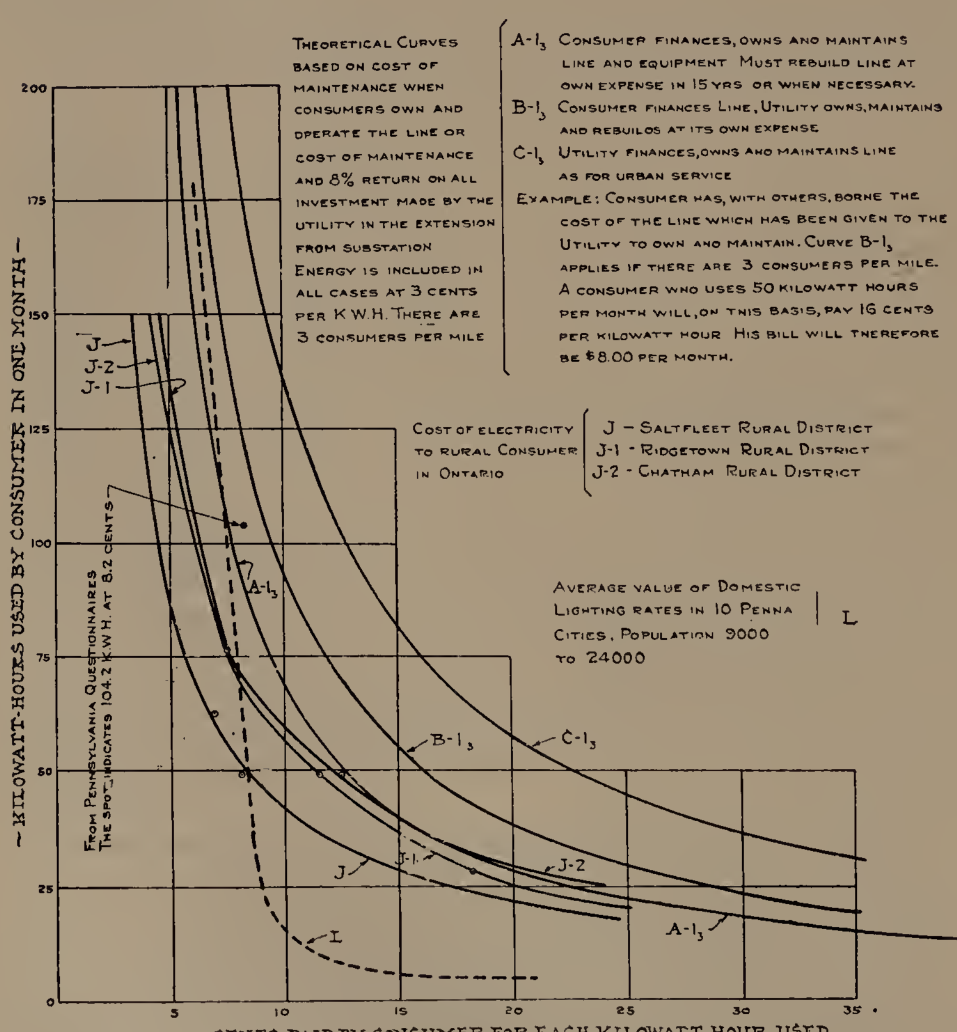


FIG. 1

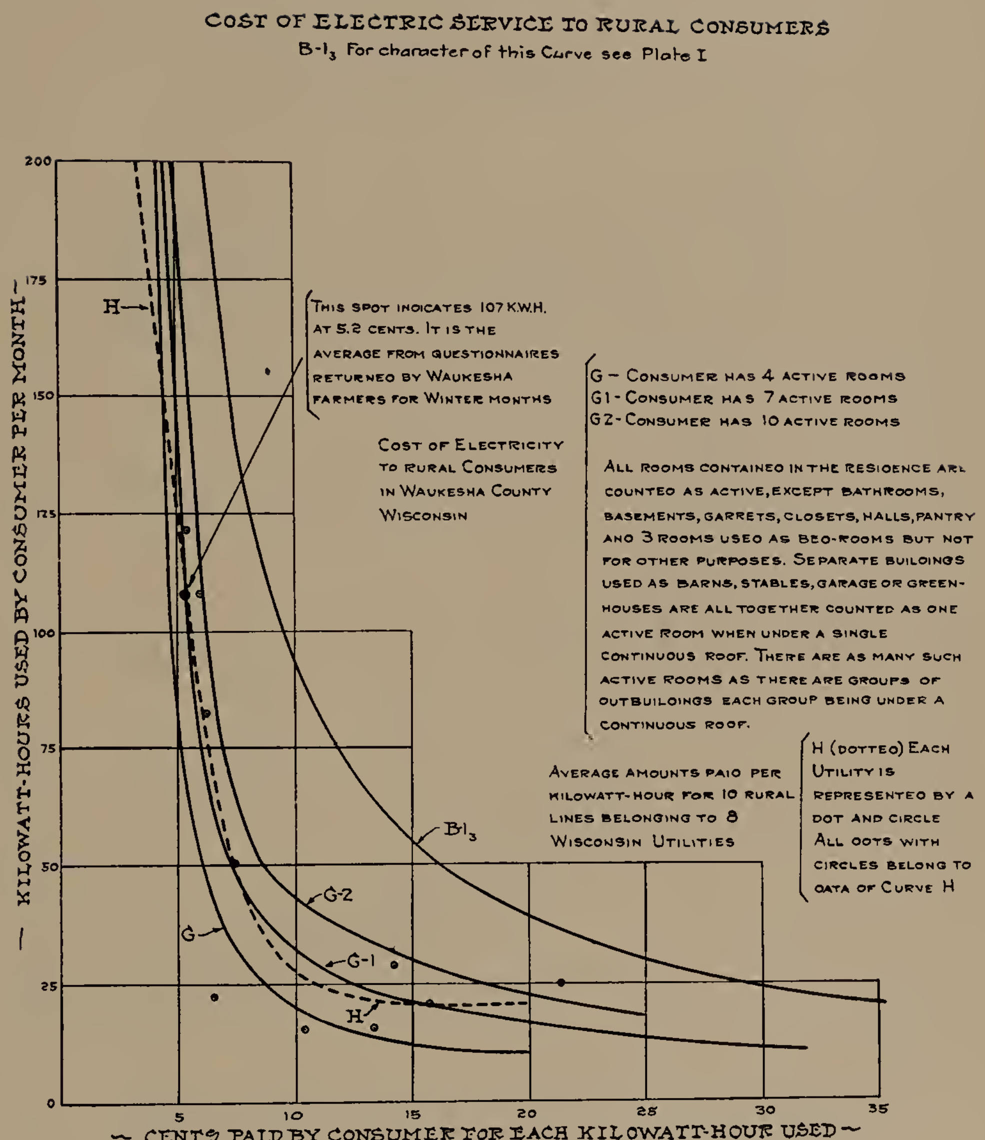

COST OF ELECTRIC SERVICE TO RURAL CONSUMERS
B-I3 For character of this Curve see Plate I
THIS SPOT INDICATES 107 K.W.H. AT 5.2 CENTS. IT IS THE AVERAGE FROM QUESTIONNAIRES RETURNED BY WAUKESHA FARMERS FOR WINTER MONTHS
G – CONSUMER HAS 4 ACTIVE ROOMS
G1 - CONSUMER HAS 7 ACTIVE ROOMS
G2 - CONSUMER HAS 10 ACTIVE ROOMS
COST OF ELECTRICITY TO RURAL CONSUMERS IN WAUKESHA COUNTY WISCONSIN
ALL ROOMS CONTAINED IN THE RESIDENCE ARE COUNTED AS ACTIVE, EXCEPT BATHROOMS, BASEMENTS, GARRETS, CLOSETS, HALLS, PANTRY AND 3 ROOMS USED AS BED-ROOMS BUT NOT FOR OTHER PURPOSES. SEPARATE BUILDINGS USED AS BARNS, STABLES, GARAGE OR GREEN-HOUSES ARE ALL TOGETHER COUNTED AS ONE ACTIVE ROOM WHEN UNDER A SINGLE CONTINUOUS ROOF. THERE ARE AS MANY SUCH ACTIVE ROOMS AS THERE ARE GROUPS OF OUTBUILDINGS EACH GROUP BEING UNDER A CONTINUOUS ROOF.
H (DOTTED) EACH UTILITY IS REPRESENTED BY A DOT AND CIRCLE ALL DOTS WITH CIRCLES BELONG TO DATA OF CURVE H
AVERAGE AMOUNTS PAID PER KILOWATT-HOUR FOR 10 RURAL LINES BELONGING TO 8 WISCONSIN UTILITIES
H
B-I3
G-2
G-1
G
H
KILOWATT-HOURS USED BY CONSUMER PER MONTH
200
175
150
125
100
75
50
25
0
5
10
15
20
25
30
35
CENTS PAID BY CONSUMER FOR EACH KILOWATT-HOUR USED

FIG. 2

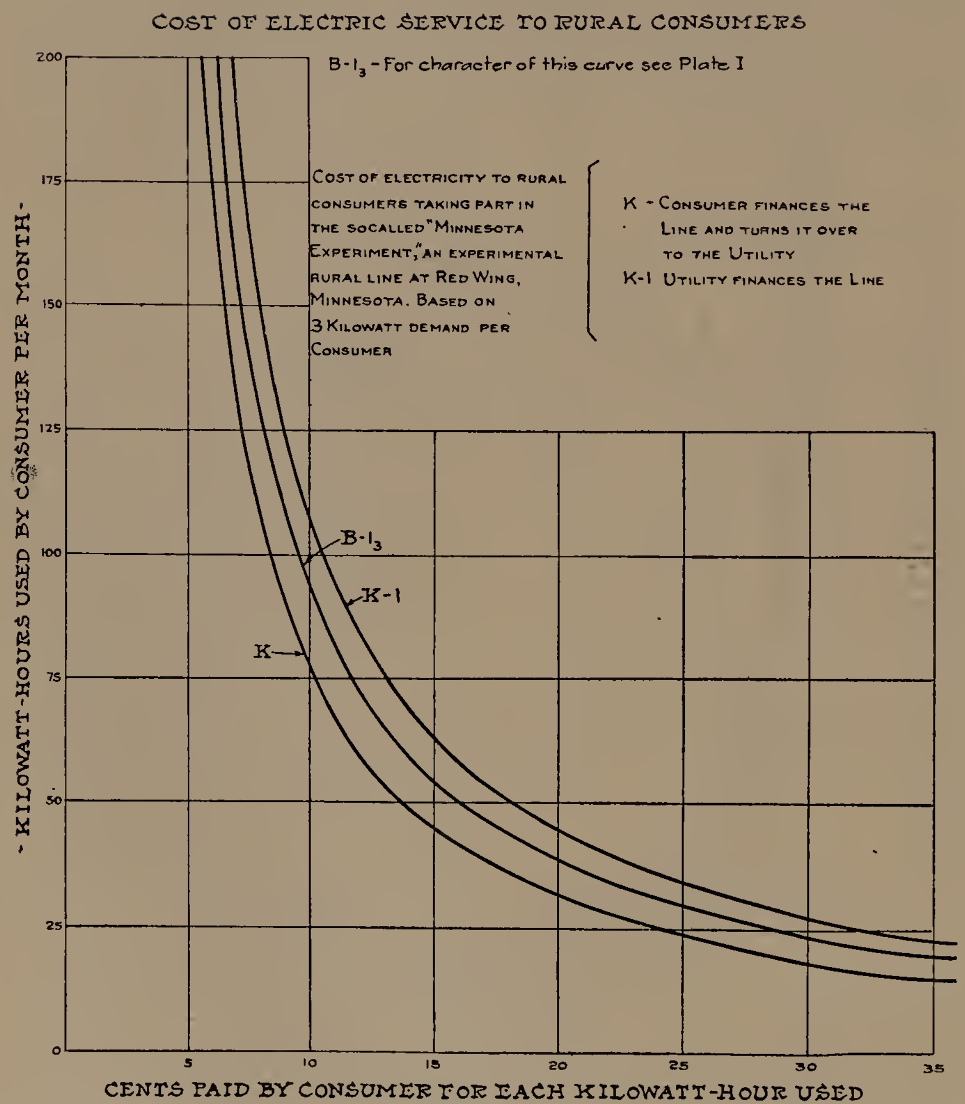

COST OF ELECTRIC SERVICE TO RURAL CONSUMERS
B-I_3 - For character of this curve see Plate I
COST OF ELECTRICITY TO RURAL CONSUMERS TAKING PART IN THE SOCALLED "MINNESOTA EXPERIMENT," AN EXPERIMENTAL RURAL LINE AT RED WING, MINNESOTA. BASED ON 3 KILOWATT DEMAND PER CONSUMER
K - CONSUMER FINANCES THE LINE AND TURNS IT OVER TO THE UTILITY
K-1 UTILITY FINANCES THE LINE
B-I_3
K-1
K
200
175
150
125
100
75
50
25
0
5
10
15
20
25
30
35
- KILOWATT-HOURS USED BY CONSUMER PER MONTH -
CENTS PAID BY CONSUMER FOR EACH KILOWATT-HOUR USED

FIG. 3

EMPIRICAL FORMULAE USED IN COST OF CURRENT CURVES

A-1_3 $$C=\frac{490}{K}+2.75$$

B-1_3 $$C=\frac{600}{K-2.5}+3.3$$

C-1_3 $$C=\frac{1150}{K+5}+2$$

L $$C=\frac{35}{K-1.25}+7.5$$

J $$C=\frac{345}{K-3}+1$$

J-1 $$C=\frac{500}{K+1}+1.3$$

J-2 $$C=\frac{490}{K-3.75}+1$$

H $$.003812\ K^2+(.1962\ C-1.389)\ K=.0953\ C^2+.5662\ C+4.091$$

G $$C=\frac{90}{K-5}+4$$

G-1 $$C=\frac{190}{K-4}+3.5$$

G-2 $$C=\frac{250}{K-7.5}+3.5$$

K $$C=\frac{455}{K-4}+3.5$$

K-1 $$C=\frac{725}{K}+3.2$$

C=cents per kwh.
K=kwh. used per month.

Appendix C

1. A STUDY OF THE AMOUNT OF ELECTRIC CURRENT CONSUMED WITH SPECIAL REFERENCE TO THE PRICE CHARGED

BY BENJAMIN H. WILLIAMS, PH.D.

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The great, all-absorbing desire of the modern nation is to be the manufactory for the world's goods. Nearly all national economic policies center around this ambition. No country which aspires to this status can afford to neglect in the slightest degree the sources of industrial power. In this struggle electricity will play its part, and an important part it is sure to be. The electrified nation of the future will not only possess a great industrial advantage, but it will also be composed of happier people, liberated from the back-breaking toil and inconveniences of the past.

In contemplating the probable effects of Giant Power it seems proper to inquire as to how far the lowered rates made possible by greater economies and large scale generation will result in hastening the process of electrification, which, after all, should be the aim of this movement. It has been the purpose in writing this paper to examine some of the available data and to attempt to draw a few conclusions as to the influence of rate levels upon the amount of current consumed in the fields of electric lighting and power.

Since electricity has been sold commercially there have been two concurrent tendencies in the sales field. The price per kwh. has decreased, while at the same time the quantity sold has increased. Not many years ago commercial lighting rates were fixed as high as twenty cents per kwh. and more; and the current used was limited. Electricity was a luxury enjoyed by the few and in small amounts. Since then prices have been cut, due to a variety of causes, and quantities consumed have increased to an extent that would have been utterly impossible under the old rates.

Several causes have contributed to the increase in consumption, the reduction in rate schedules being but one of them. The education of the public to require electricity for household purposes, the development and rapid electrification of industry, the realization of the advantages of electricity for street and sign lighting, all of these have helped to expand the market for current. Furthermore during the last ten years the rise of prices, with which electrical rates have not kept pace, and the consequent shrinkage of the dollar have brought about real rate reductions. The increased amount consumed per customer in connection with the step rate system has also lowered the average price paid per kwh., without any change in the published rates.

The reduction of rate schedules in electricity has likewise been one of the most potent forces in shaping the destiny of the industry. A study of the rate question brings forth a volume of evidence on this point. Many com-

panies have undertaken development campaigns preceded by the lowering of prices to stimulate use. This is well illustrated by a statement of Joseph B. McCall, President of the Philadelphia Electric Company, quoted in the *Electrical World* (Vol. 79, p. 700). In announcing a reduction of rates Mr. McCall said: "In making this reduction we feel that this is the time to introduce the element of lower costs in production in the belief that it may serve as a real stimulus for the industrial revival which should hopefully be anticipated by everyone."

The giving of low rates to power users has frequently received sanction by Public Service Commissions as an inducement in the development of the off-peak load. The step rate, now so generally adopted, is based upon the principle that rates have a practical effect upon use, and the testimony of officials as well as experience, shows that the creation of a low second step will certainly result in an increase in consumption. The granting of lower rates for a high load factor, long burning and daytime lighting service and for cooking and heating is an established policy with many companies, entered into for the purpose of expanding particular kinds of business. Instances may be cited in which hydro-electric power developed for irrigaton purposes during the summer months has during the winter been offered to the public at extremely low rates, resulting in an unparalleled increase in the use of electricity for lighting, cooking and heating.

The experience of the Light Department of Tacoma, Washington in operating the municipal system of that place illustrates how sales of electricity may be increased by low rates. In 1915 the rates were lowered for resident users so that a combination lighting and cooking rate of 5 cents for the first step and 1 cent for the second step was secured. For strictly commercial lighting the rate was graded from 4.5 cents to 1.32 cents per kwh. The average rate for both residential and commercial lighting has dropped below 3 cents under these schedules. Coincident with this reduction the curves showing use have shot up until there has been brought about a remarkably large per capita consumption of electricity for lighting in that city. In 1921 the use per customer for resident and commercial lighting had reached 915 kwh. and the use per inhabitant was about 246 kwh. The significance of these figures will be better appreciated when they are contrasted with those for the other municipalities dealt with in this report. The average rate for commercial lighting is lower than that for any other American municipality shown and the use per customer and per inhabitant is substantially greater.

An interesting phase of the rate reduction program in Tacoma aside from that of lighting has been the development of electrical house heating. A rate of ½ cent with a minimum charge of $9.00 per kw. of demand per year was established in order to meet the popular request and to dispose of the surplus current from water power development. In 1921 there were 1,978 heating customers who were using on the average 9,470 kwh. each per year at an average rate of .552 cents per kwh. The City Light Department expresses an opinion that so long as the heating load is small as compared with the lighting, cooking and power loads, it will be possible to maintain the low

rates for heating. However, if the heating load should begin to exceed the others it would result in difficulties for the system. At the time of the issuance of the latest Information Book of the Light Department for the year 1922-23 new heating business was being refused.

The City of Springfield, Illinois, reports similar results from the lowering of rates. An investigation of the accounts of 180 typical customers showed that following the rate reductions the number of kwh. per customer gradually increased over a period of six years from 194 to 400. The number of customers meanwhile increased from less than 7,000 to more than 18,000. City officials attribute a large part of this development to the cheaper price. To quote the words of Willis G. Spaulding, Commissioner of Public Property: "I think it might fairly be said that the low rates have resulted in doubling the number of consumers and popularizing the use of current so that the average consumer uses about double as much as formerly."

An account of the results of rate changes made by the Hartford Electric Light Company is given in the *Electrical World* for April 21, 1923, (p. 917). In December, 1920, an increase in rates for domestic lighting was made. This raise in rates was followed by a marked decrease in the percentage of monthly increases of use. In January, 1922, the rate was substantially cut for the purpose of developing domestic lighting business. This lowering of rates was followed by a noticeable increase in the percentage of monthly increases of kwh. used. A graphic illustration accompanying the article shows very clearly the results of the rate changes upon the development of the company's business.

With regard to commercial lighting, which term includes the wide variety of domestic uses as well as store, window and sign lighting, the tendency to development has two aspects. In the first place there are certain old and well established needs which are now being taken care of by other means, which however, electricity may conceivably supply. This is true of lighting, cooking and heating. Here rates become important to the prospective customer when the relative cost of electricity as compared with kerosene, gas, coal and wood comes into consideration, although the convenience of electricity gives it an undoubted advantage. In the second place there are certain new needs which are being created, the filling of which is not, in the beginning at least, considered essential. This class includes the use of current for household accessories, additional lighting and electric signs. The question of price here is also important, as it always is in the purchase of utilities which are not considered necessities.

In the possible development of industrial power, rates are important because the relation of the costs of electricity and steam will determine to a large extent the progress of the invasion of electricity into this field. In Ontario, for example, where coal is high and electrical rates are low, this invasion went forward rapidly until practically the whole field of industrial power was taken over by electricity. In Massachusetts where both coal and electricity are comparatively high, steam power has been able to offer more stubborn resistance, although much progress has been made by the central stations. It may also be expected that low rates will enlarge the amount of

power used by increasing the ratio of machine power to man power in industry and by attracting new industries to localities where electricity is cheap

Could communities with different rates but with all other conditions equal be contrasted we should find without doubt not only that rates had a considerable effect upon consumption but also that this effect could be accurately predicted. Some years ago William D. Marks, of Philadelphia, a scholarly executive in the electrical industry, made some interesting researches with regard to this matter. His conclusions were that lowered rates were a great stimulus to increased use and resulted in substantial benefits to the community. From a study of average rates and sales for all purposes in fifteen Massachusetts cities for 1908 he reduced the effect of rates upon per capita use to a formula, which was designated, Marks' Empirical Law of Demand, and was expressed in the following equation:[1]

Let s=the sales per capita in kwh., and p the average price.
Then $s=(640 \div p)-45$.

The working of this equation is illustrated as follows:

				Difference for 1 cent.
If p= 4	cents,	s=115	kwh.	
" p= 5	"	s= 83	"	—32
" p= 6	"	s= 62	"	—21
" p= 7	"	s= 46	"	—16
" p= 8	"	s= 35	"	—11
" p= 9	"	s= 26	"	— 9
" p=10	"	s= 19	"	— 7

Such an equation will not work accurately for cities of different character which are situated in dissimilar sections of the country, and unless revised it would not be usable today for Massachusetts cities because of the changes in the industry. But it gave approximate results at the time of Mr. Marks' calculations, and demonstrates the close relationship which exists between price and quantity of current consumed, which, with other factors equal, can be definitely expressed. This relation arises for the most part from the causative force of lower rates in bringing about larger consumption, but also partly from the effect of large scale production in making lower rates possible.

In undertaking the investigation of the subject in this paper a number of cities and smaller municipalities in three diverse sections, Massachusetts, Wisconsin and Ontario, have been chosen for study. The reasons for choosing these three communities are the considerable differences that exist among them in rate levels and the excellent records of operating statistics that have been maintained by governmental agencies in each. Ten cities of intermediate size and ten smaller municipalities have been chosen for study in each section, making a total of sixty communities in all. In comparing these with their widely varying rate schedules, much can reasonably be deduced with regard to the effect of rates upon electrical progress. Statistics are set forth in each instance for the years 1914, 1918, and 1921 excepting that in Wisconsin for the first two periods data were compiled for the years ending June 30,

[1]*Electrical World*, Vol. 54, p. 555.

1915 and June 30, 1919. This period shows pre-war, war time and post-war operations.

It must be kept in mind that during this time abnormal forces were brought to bear upon American industry, which had a profound effect upon operating statistics. Furthermore, the use of electricity for power purposes made rapid advances. In fact power ceased to be a by-product, disposed of at a low figure as an off-peak load, and became a main consideration, if not the main consideration, in the policies of central station executives. War time prosperity and the education of the people to "do it electrically" increased the use for domestic purposes and commercial lighting. The total growth was impressive. In 1914 the public utility plants in the United States produced 14,400,000,000 kwh. This production grew to 31,450,000,000 in 1918 and to 40,976,000,000 in 1921, a gain during the period of 185 per cent.

Throughout the statistics examined differences have been observed in the rates charged by municipally owned and privately owned systems. Without entering into the controversy raging around the question of municipal ownership a generalization may be hazarded that the municipal plants react more to the demands of the small consumer while under private ownership the emphasis is placed upon serving the large power consumer cheaply. Under private ownership there will therefore be a wider gap between power rates and those charged for domestic use. Undoubtedly this difference can be traced to the controlling factors behind each system. The political influence in case of the municipal plant causes respect for the desires of the small consumers, but the private central station operator can bargain to his greater advantage with the public than he can with the large power users who are free either to develop their own current or to use steam.

Following is a summary of certain relevant operating statistics of the communities considered for the year 1921. It may be noticed that the power statistics for Ontario are not included as they are not comparable, being stated in terms of H. P. while those for the other places are in terms of kwh.

ALL COMMUNITIES—1921

COMMERCIAL LIGHTING

	Population	No. of customers	No. per 100 pop.	Kwh. sold	Av. rate	Kwh. per cust.	Kwh. per inhab.
Mass. cities	947,315	105,155	11.1	45,250,361	9.32	430	48
Mass. smaller municipalities .	50,446	7,808	15.5	1,677,926	....	215	33
Wis. cities	287,214	60,786	21.2	30,426,783	7.11	501	106
Wis. smaller municipalities .	56,994	13,598	23.8	4,364,331	10.53	313	77
Ontario cities ..	432,828	76,813	17.7	66,952,434	1.9	872	155
Ontario smaller municipalities .	48,277	10,318	21.4	7,530,069	2.3	730	156
			POWER				
Mass. cities	947,315	6,269	.66	142,337,509	3.12	22,705	150
Mass. smaller municipalities .	50,446	353	.70	4,949,372	....	14,021	98
Wis. cities	287,214	2,614	.91	69,665,312	2.41	26,651	243
Wis. smaller municipalities .	56,994	813	1.42	11,836,027	3.51	14,558	208

MASSACHUSETTS CITIES

Commercial Lighting—The cities chosen for this study are: Cambridge, Brockton, Fall River, Fitchburg, Holyoke, Lowell, Lynn, Malden, Pittsfield and Salem. The summarized figures for these ten for the years 1914, 1918 and 1921 are as follows:

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1914	848,461	45,842	5.4	22,044,717	8.55	481	26
1918	919,478	77,832	8.5	30,641,584	8.20	394	33
1921	947,315	105,155	11.1	45,250,361	9.32	430	48
Increase ...	11.7%	129%	5.7	105%	.77¢ or 9%	—18%	85%

The quoted rates, which are not given in the summarized tables but which are indicated in the detailed tables[1] Nos. 1, 2 and 3 are comparatively high, the maximum net price per kwh. being on the average about ten cents. The average rates are likewise high, varying from 8:55 cents in 1914 to 9.32 cents in 1921. The results of high rates are clearly reflected in the restricted consumption, the amount of current used being 26 kwh. per inhabitant in 1914 and 48 kwh. per inhabitant in 1921. These figures appear quite low when they are contrasted with the per capita consumption for commercial lighting in other sections where the rates are less.

In contrasting the figures for the various cities significant differences may be seen. There is considerable departure from the general level of rates in the case of Holyoke, which charges six cents per kwh. Both the quoted rate and the average rate are much below the others and a free use of electricity for commercial lighting appears to be made in that city. Taking the 1921 figures (Table 3) the average rate per kwh. for all cities is 9.32 cents while in Holyoke it is 6.15 cents. The number of customers per 100 population is 11.1 for all of the cities, while in Holyoke it is 16.6. The number of kwh. per inhabitant is 48 for all the cities as compared with the Holyoke figure of 81. The number of kwh. per customer is 430 for all of the cities and 486 for Holyoke. Holyoke exceeds all other cities in the number of customers per 100 population and in the kwh. per inhabitant, and ranks fourth in kwh. per customer. The latter figure is not particularly significant with regard to the effect of rates upon consumption, as frequently a city with high rates will show a comparatively generous consumption per customer; the list of customers being limited to the comparatively well to do. As the ranks of customers are extended to take in a greater proportion of the population the number of kwh. consumed per customer will frequently decrease, although the total consumption for the community greatly increases.

Glancing at the summary tables of statistics for the three years we find that the tendency was towards increase in the use of electricity. The

[1]These supporting tables and other data assembled in connection with this study may be consulted in the office of the Giant Power Survey at Harrisburg.

number of customers more than doubled, as did also the sales. The consumption per inhabitant increased 85% and the consumption per customer decreased 18%. These figures indicate progress in spreading the use of electricity throughout the community. At the same time there was a tendency to raise rates. The only marked reduction effected was in the case of the Edison Company at Brockton where the maximum net price was reduced three cents. In that city the average rate fell from 9.75 cents to 8.05 cents. The statistics of development show that there was a greater increase in use of electricity per capita in that municipality than in any other excepting Holyoke. In all other cases the average price per kwh. increased, due partly to rate increases and partly to the reduction of consumption per customer. The average rates increased from 8.55 to 9.32 cents.

Notwithstanding the raising of rates there was a substantial growth in number of customers and in kwh. sold. The customers increased from 45,842 to 105,155, a gain of 129%. The sales increased from 22,044,717 to 45,250,361, a gain of 105%. This is partly due to the increase in population which was 11.7% during this period but nevertheless, the kwh. per capita increased from 26 to 48, a gain of 85%. These increases show the effect of other influences than reduction of rates.

Power—The following table shows the summary of operating statistics for commercial power for the same ten cities during the same period.

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1914 ...	848,461	3,275	.39	48,406,792	2.31	14,781	57
1918 ...	919,478	4,464	.49	121,608,317	2.04	27,242	132
1921 ...	947,315	6,269	.66	142,337,509	3.12	22,705	150
Increase.	11.7%	92%	.27	194%	35%	54%	163%

Here again we have comparatively high rates, the average in 1921 being 3.12 per kwh. The kwh. sold average 150 per inhabitant. A comparison of rates for the various cities which are indicated in Table 9 shows that among the various cities lower rates are generally, though not always, followed by a greater use of electricity for power purposes.

Comparing the totals for the three years we find the same phenomenon as noticed in commercial lighting; a great increase in sales in spite of a material increase in rates. This period saw the common introduction of coal clauses. The average rates were raised 35%. The number of customers increased 92%, the sales increased 194% and the kwh. per inhabitant were raised 163%. During these years much was done in introducing electricity into the textile mills and other industries of Massachusetts.[1] This movement went forward rapidly in spite of the resistance of higher rates, for at the same time the cost of coal was rising and steam power was also becoming more expensive.

[1]For an interesting account of the electrification of textile mills during this time in a New England city see: The Central Station and the Textile Mill, Electric Journal, Vol. XVIII, page 487.

Smaller Municipalities

Commercial Lighting—The ten smaller communities of Massachusetts chosen for study are: Amesbury, Ayer, Harvard, Norton, Randolph, Seekonk, Spencer, Williamsburg, Williamstown, and Winchendon. The summary is as follows:

	Population	No. of customers	No. per 100 population	Kwh. sold	Kwh. per customer	Kwh. per inhabitant
1914	45,759	2,506	5.5	655,421	261	14
1918	45,178	5,380	11.9	1,283,145	239	28
1921	50,446	7,808	15.5	1,677,926	215	33
Increase ..	10.2%	212%	10.00	156%	—18%	136%

These communities are representative of Massachusetts in that rates are extremely high. The average rates are not shown in the Massachusetts report for these municipalities; but the quoted rates are the highest of those considered in this paper, the general level being well above 12 cents. Very little electricity is used for commercial lighting in these communities, the number of kwh. sold per inhabitant amounting to 33 in the year 1921. In Harvard, to take the extreme instance, the exceeding high rate of 18 cents is quoted for 1921 and the use per inhabitant is 10 kwh. When this is compared with communities of the same size in Ontario, Canada where the rates are in the neighborhood of 2 and 3 cents and where the consumption for commercial lighting per inhabitant runs as high as 100 kwh. or more the effect of high and low rates upon the socialization of electrical current may be readily appreciated.

When the statistics of the smaller communities are compared with those of the Massachusetts cities where the rates are somewhat less it may be seen that the city dweller makes substantially more use of electricity for commercial lighting.

Comparing the tables for the three years, 1914, 1918 and 1921 we find, as in the cities, a very encouraging increase in sales, although there is in general a raise in rates. The number of consumers increased from 2,506 to 7,808, a gain of 212%; the kwh. sales increased 156% and the kwh. per inhabitant increased 136%. Here again influences other than rates caused the increase. A study of such communities where raised rates have been accompanied by such progress in sales might lead to the conclusion that rates have little effect upon development. However, we shall find that in communities where rates have decreased the progress of development has been more rapid.

Power—Following is the summary of the experience of these communities with regard to power.

	Population	No. of customers	No. per 100 population	Kwh. sold	Kwh. per customer	Kwh. per inhabitant
1914	45,759	162	.35	1,317,903	8,125	29
1918	45,178	320	.71	4,373,243	13,666	97
1921	50,446	353	.70	4,949,372	14,021	98
Increase ...	10.2%	118%	.34	276%	73%	238%

An examination of Tables 10, 11 and 12 where the quoted rates are given in detail for these three years will show that the rates were lowered during

this period in a number of cases. The summary above shows the increase in the use of power, the kwh. sales increasing 276% and the kwh. per inhabitant 238%. This is a considerably greater increase than occurred during the same time in the Massachusetts cities where rates were raised.

Wisconsin Cities

Commercial Lighting—The ten Wisconsin cities chosen for study are Beloit, Eau Claire, Green Bay, Janesville, Kenosha, La Crosse, Madison, Marinette, Oshkosh and Superior. The summary of their experience in commercial lighting for the years ending June 30, 1915, June 30, 1919 and Dec. 31, 1921 is as follows:

	Population	No. of customers	No. per 100 population	sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1915	237,940	32,163	13.52	14,199,969	6.97	441	59
1919	287,214	45,150	15.7	20,145,483	6.76	446	70
1921	287,214	60,786	21.2	30,426,783	7.11	501	106
Increase ..	(1)	89%	(1)	114%	2%	—14%	(1)

(1) No attempt is made to estimate increases in relation to population as the census figures of 1910 and 1920 only are used for population.

Comparing this summary with the summary for Massachusetts cities it may be observed that the average rate charged is substantially less in Wisconsin. For 1921 the Wisconsin average rate was 7.11 while the rate for the ten Massachusetts cities was 9.32. During the same year the kwh. per inhabitant in the Wisconsin cities amounted to 106 while in the Massachusetts cities the figure was 48. There can be little doubt but that the substantially lower rates in Wisconsin contributed to this difference.

The progress of commercial lighting during the three years was encouraging, the sales increasing 114%. This cannot be ascribed to rate reductions, however, as the average rate was almost stationary, increasing only by 1.4 mills.

The detailed statistics contained in Table 15 show that the rates for Madison are substantially below those of the other cities, and it is interesting to note that that city has had a considerably higher number of kwh. per inhabitant than any other, the 1921 figure being 192 for Madison as compared with 106 as an average for the whole group.

Power—Following is a summary of power statistics for the ten Wisconsin cities.

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1915	237,940	1,680	.706	40,300,089	1.48	23,988	169
1919	287,214	2,295	.80	58,326,915	1.98	25,415	203
1921	287,214	2,614	.91	69,665,312	2.41	26,651	243
Increase .	(1)	56%	(1)	73%	64%	11%	(1)

(1) No attempt is made to estimate increases in relation to population as the census figures of 1910 and 1920 only are used for population.

Comparing this table with tables of the ten Massachusetts cities it is plainly seen that throughout this period Wisconsin industry has been more

fully electrified. The kwh. per inhabitant for the years under consideration are 169, 203 and 243 respectively in Wisconsin as contrasted with 57, 132 and 150 in the Massachusetts cities. A comparison of average rates will show that during the same years the price paid for power was considerably less in Wisconsin. During these years rates increased in both states, but by a higher percentage in Wisconsin. The use of power increased in both states but much more greatly in Massachusetts, the increase there of total sales being 194% as against 73% for the Wisconsin cities. It is probable that this greater increase in Massachusetts was due to the fact that the increase of rates was not so great in proportion as in Wisconsin, and also because at the beginning of the period Massachusetts industry offered greater opportunities for electricity, as the electrification of mills in Massachusetts had not been carried so far as in Wisconsin.

Smaller Municipalities

Commercial Lighting—The small communities studied in Wisconsin are: Antiago, Baraboo, Berlin, Burlington, De Pere, Mayville, Menomonie, Monroe, Platteville and Waukesha. Following is the summary of operating statistics:

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1915	50,765	7,396	14.57	2,142,259	9.42	290	42
1919	56,994	10,440	18.3	3,150,296	9.17	301	55
1921	56,994	13,598	23.8	4,364,331	10.53	313	77
Increase ..	(1)	84%	(1)	104%	12%	8%	(1)

(1) No attempt is made to estimate increases in relation to population as the census figures of 1910 and 1920 only are used for population.

Comparing this table with that for the ten smaller municipalities in Massachusetts it cannot escape attention that the Wisconsin small town uses considerably more electricity than its prototype in Massachusetts, whose rates are considerably more. Comparing the Wisconsin small towns with the Wisconsin cities where the average rates are from 2 to 3 cents per kwh. less we find that here again the city dweller is using more electricity for commercial lighting, the kwh. consumption per inhabitant being in 1921, 106 in the cities as against 77 in the smaller municipalities.

During this period the average rates increased 12% and at the same time the kwh. sales increased 104% and the kwh. per customer 8%. Contrasting the communities with one another in Table 18 we find the unusual situation that those with lower rates do not seem to have a greater consumption, local differences, no doubt, interfering with the ordinary rule.

Power—Following is a summary of operating statistics of power sales.

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1915	50,765	462	.91	13,952,351	2.43	30,200	275
1919	56,994	623	1.09	26,783,228	2.52	42,991	470
1921	56,994	813	1.42	11,836,027	3.51	14,558	208
Increase ...	(1)	76%	(1)	—15%	44%	—52%	(1)

(1) No attempt is made to estimate increases in relation to population as the census figures of 1910 and 1920 only are used for population.

The outstanding changes shown for the years mentioned are a material increase in rates and a great rise in amount of current used for 1919 followed by a drop for 1921. This fluctuation was due to the war. Tables 22, 23 and 24 from which the above is compiled show that the greatest part of the increase for 1919 and decrease for 1921 is due to the community of Platteville. According to information courteously furnished by the Wisconsin Railroad Commission, Platteville is the center of an extensive lead and zinc mining region. These minerals are essential to war operations and were in great demand during the conflict. After the war practically all of the mines in this section were closed and the use of power fell from 18,517,541 kwh. in 1919 to 4,223,885 in 1921. Industrial reactions at one or two of the other communities helped to cut down the current in 1921. The failure of quarries and gravel pits at Waukesha to operate at full capacity and the decrease in the use of electricity by the Waukesha Motor Company account for a falling off in the figures for that municipality. Despite the unusual influence of one or two communities on the totals, the Wisconsin Railroad Commission considers that the statistics are typical of those for all the smaller communities of Wisconsin during this period.

The fall in the use of current for power purposes was accompanied by an increase in rates which tended partially to offset the loss in revenues. It will be noted that the average rate rose from 2.43 cents in 1915 to 3.51 cents in 1921. Manifestly the increase in rates was not a cause of the fluctuation in the use of current. The experience of these municipalities well illustrates the fact that the power load is frequently more dependent upon unusual demands of industry than upon the rates charged.

ONTARIO CITIES

Commercial Lighting—In Ontario we find a most striking example of the democratization of electricity through lower rates. Here we encounter not only extremely low rate schedule but also a reduction in rates during the period under consideration. The result is an unusually large consumption by the public and an unusually high percentage of increase during the period 1914-21.

The Ontario cities selected for consideration are Brantford, Galt, Guelph, Hamilton, Kitchener, London, Ottawa, St. Catherines, St. Thomas and Stratford. The summary of operating statistics is as follows:

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1914	384,867	36,749	9.6	12,130,075	4.2	330	31
1918	388,061	61,566	15.8	32,646,235	2.3	530	84
1921	432,828	76,813	17.7	66,952,434	1.9	872	155
Increase ...	12%	109%	8.1	452%	—55%	164%	400%

During the year 1921 the average rate was 1.9 cents as compared with 9.32 cents for Massachusetts cities and 7.11 cents for Wisconsin cities. The results are reflected in the kwh. consumed per customer which average 872 as compared with 430 and 501 for the Massachusetts and Wisconsin cities respectively, and in the kwh. per inhabitant which are 155 as compared with

48 and 106 for the Massachusetts and Wisconsin cities. This large use is due to the studied attempt of the Hydro-Electric Power Commission of Ontario to popularize electricity through low rates and has resulted in an enormous use of electricity in the home.

A study of the progress of electric lighting in Ontario rveeals a rapid multiplication of kwh. consumed coincident with the installation of the Commission's program of rate reduction. The charge for electricity prior to the present Hydro project varied from 7 to 12 cents per kwh. for the cities under consideration with an additional service charge in most cases. An examination of Tables 25, 26 and 27 will show how far the rates have been reduced below this level in reaching their 1921 average of 1.9 cents. The development of consumption from the meager amounts which preceded the Hydro Commission to the large figures of today is an exceedingly instructive movement. It was stated above that the use of electricity has increased during the last few years even in those communities where rates remained stationary or showed actual increase. The figures for Massachusetts showed an increase of 105% during the years under consideration while their average rates were increasing 9%. The Ontario cities with an average rate reduction of 54% showed an increase in kwh. of 452% which is far more rapid than the normal increase in other parts of the country, and this increase is still going on as shown by the 1923 figures which are now available.

Power—The basic reason for the systematic development of water power by the provincial government in Ontario has been the desire to furnish a substitute for coal which will enable the province to progress industrially despite the lack of fuel. In the past, coal fields have been coveted by statesmen as being the great source of industrial power. The desperate conflict of policies in Europe has centered largely around the rich fields of the Ruhr, the Saar and Upper Silesia. In the Far East the coal of China has had much to do with the ambitions of Japan toward her great neighbor; and those ambitions are all important in Far Eastern politics. The coal field has been universally prized because like a huge magnet it draws all the industries to itself and the ambition of nationalists today is to create manufacturing centers within their own boundaries, thus providing a labor market in times of peace, securing the independence of the country and strengthening its military resources in times of war.

The Canadian has not been satisfied that his industrial future should depend upon imported coal. The work of the Ontario Hydro-Power Commission is, in its striving for industrial emancipation, as truly an expression of Canadian nationalism as was the rejection of reciprocity in 1911. The very noteworthy efforts of that commission as well as the equally noteworthy developments under private initiative in Quebec hold much significance for the student of national policies. These are the efforts of an ambitious and potentially great people to create for themselves the sources of power and to refute the dogma that industrialism without coal is impossible. The United States, richer than all other nations in both coal and water power, can only wish them success in their endeavors and profit by their example.

Since the program of the Hydro-Power Commission has gone into effect

the comparative cheapness of electric power coupled with the scarcity of coal has resulted in the increasing use of electricity for power until the industries of Ontario have been completely electrified. The steam engine has become almost obsolete. As stated before, the power statistics of Ontario are not set forth in terms of kwh. and are therefore not comparable with the statistics for Massachusetts and Wisconsin. Complete figures were obtained, however, for the City of Toronto through the Toronto Hydro-Electric System and these are here set forth.

Population	No. of customers	No. per 100 population	Kwh. sold for commercial power	Aver. rate	Kwh. per customer	Kwh. per inhabitant
522,942	2,488	.48	91,722,614	1.35	36,866	175

Smaller Municipalities

Commercial Lighting—The municipalities under consideration are: Acton, Barrie, Brampton, Coldwater, Collingwood, Dundas, Hespeler, Preston, Waterloo and Welland. The summary of operating statistics is as follows:

	Population	No. of customers	No. per 100 population	Kwh. sold	Aver. rate	Kwh. per customer	Kwh. per inhabitant
1914	44,440	5,652	12.7	1,689,538	5.5	299	38
1918	45,751	8,012	17.5	3,386,226	3.2	423	74
1921	48,277	10,318	21.4	7,530,069	2.3	730	156
Increase	9%	83%	8.7	346%	—58%	144%	311%

These smaller communities simply repeat the experience of the larger communities, not only in the cheapness of current but also in the rapid development of the commercial lighting business. They duplicate the experiment of showing what low rates will accomplish in bringing the advantages of electricity into the home and lightening the burdens of domestic work. The number of kwh. consumed per inhabitant in 1921 was 156 as contrasted with 33 in the Massachusetts smaller towns and 77 in the smaller municipalities in Wisconsin. The average rate was reduced 58% and the number of kwh. increased 346%, as shown by the summary.

II. AESTHETIC CONSIDERATIONS ON USE OF GIANT POWER

A discussion by a Committee of the American Institute of Architects of the problem of making Giant Power developments without spoiling the natural loveliness of rural scenery

On the assumption that in the very near future power stations and electric transmission and distribution lines are to be carried to parts of the State heretofore without them and that existing facilities are to be quite generally scaled up in size the Giant Power Survey requested the American Institute of Architects to make a study of the ways in which these expected

developments may be effected with the least possible detriment. One of the outstanding features of the Industrial Revolution of the XIXth Century was its utter disregard of aesthetics. In the mad rush to apply mechanical power to industry Beauty—the great solace and inspirer of the race—was pushed into the background. Our urban industrial centers have been cleared of any trace of beauty and charm as if lapped by a fire that fed on these fundamentals of decent living. As we enter on the period of the Electrical Revolution it is well to consider how we can conserve rather than destroy these great assets which, once destroyed, experience teaches are well nigh irrecoverable. To this end the report which follows has been prepared by a group of distinguished architects officially appointed by the Institute.

M. L. C.

December 4, 1924.

MR. WILLIAM B. FAVILLE, *President*,
The American Institute of Architects,
Washington, D. C.

Dear Sir:

Your special committee on cooperation with the Giant Power Survey of Pennsylvania, appointed for the purpose of studying rural electrical transmission development as to the effect it may have on the aesthetics of the American countryside, begs leave to make its report and recommendations.

The following elements have been studied with respect to present equipment and methods, and as to changes in equipment methods, design and planning which would tend to reduce or eliminate non-aesthetic features of the present types of equipment and methods of placing and embellishment:

(a) Steam operated generation plants;
(b) Water power generation plants;
(c) Substations and equipment;
(d) High voltage main transmission lines;
(e) High voltage secondary distribution lines;
(f) Low voltage distribution lines.

The practical requirements for the location of a steam operated electrical power generation plant according to present practice are that it be located on a lake or a river of fairly large dependable flow near an abundant supply of coal. Contact with a water supply is the prime necessity because of the large quantity of cool water necessary for condensation purposes.

The present importance of a large water supply can be judged from a recent statement by the power companies operating in and about Chicago in their application to the War Department for permission to fill in submerged land along Lake Michigan near the Illinois-Indiana state line. They declared that the contemplated addition to their existing power plants along the Chicago River and Calumet River would exhaust the possibilities of the use of these streams for condensation purposes and that all future locations for new generation plants must be in contact with Lake Michigan. The combined flow of these streams is upwards from 10,000 cubic feet per second.

Statements made by the Federal Power Commission point out that the possible locations for large steam plants in the coal regions of Pennsylvania are limited, because of the necessary supply of condensing water, to points along the Ohio River.

The water cooling tower as a substitute for a large natural supply of cool water has made its appearance in the power house field and will probably make possible the location of some of the power houses of the future at other points than adjacent to the large supplies of natural cool water. The natural supply of cool water will probably be utilized first however and with these

things in view the aesthetics of power house construction become of great importance.

The streams of Pennsylvania are features of landscape beauty which deserves preservation from further desecration. The construction of power plants in which the planning and design of the plant and its surroundings have not been handled by persons competent to consider properly these features, more often than not turn out to be desecrations of the beauty of the countryside. In the past, large corporations seem to have regarded any money spent on the aesthetic aspect of their plants as money wasted. At present, however, there seems to be a happy tendency toward the realization that money spent in this way gains the good will of the community to many times the extent that a like amount of money spent on advertising would accomplish. This tendency properly fostered and guided will do much to safeguard the beauty of our rural landscape.

In the opinion of your committee the proper consideration of the aesthetics of power plant construction calls for the study of each problem as to design and planning of the plant and its surroundings by competent persons rather than the production of standard designs and elaborate principles of location and landscaping to be followed without regard for the physical conditions which surround each project. It might be proper however to lay down certain principles which will serve as a guide to the preliminary studies and reconnaisance for the location of new plants.

A broad principle which applies to all plants is that they should be harmonious with their surroundings. A rural plant calls for architectural simplicity and for construction materials which blend with the landscape. An urban plant calls for architecture in tune with its surroundings. Rural plants should be located and constructed in such a way as to permit the landscape man or forester to blot out with planting the bald appearance which in the past has characterized so many of these works. In the case of the rural steam plant a proper landscaping treatment calls for an informal planting which will grow to a suficient height to cause a masking of the structure up past the base of the smoke stacks. Vistas of the building through apertures between the under foliage of the high planting and the foliage of the low planting, if properly handled, will add interest to the countryside. An orderly arrangement of tall stacks of proper material, rising out of the upper foliage of the trees would not be a disturbing element in the natural landscape composition. It is when the building is seen as a whole, unless it is architecturally very finely balanced, that the greatest harm is done. Any sluiceways which are necessary around such a structure lend themselves to treatments which will contribute to a pleasing effect.

The chimneys of these power plants, inasmuch as they are the features of the building which thrust themselves most prominently into the landscape, should receive special care as to design and material. There are many examples of good and bad chimney design in our country and the main difference between the two is that in one, appearance has been considered in the design, while in the other only practical requirements have been considered. In general, polygonal chimneys are much more interesting than round ones. The treatment of a chimney surface with a variety of harmoniously colored materials, makes for more interest and better appearance. The most important factor, however, toward good chimney design is good lines.

It is usually necessary to locate a hydro-electric plant in direct connection with a dam. Good sites are limited in number so that the aesthetic problem in connection with such plants becomes one of making the best of the situation which presents itself. Certain elements which are present in connection with hydro-electric dams, if properly handled form important additions to the landscape. Tumbling water when broken up sufficiently and in such a way as to avoid monotony always charms the human eye.

The power house should be subordinated as much as the practical requirements of the problem will allow. In those cases where the power house

is made a part of the dam, and in those other cases where the following procedure is possible, the structures should be blended with the landscape by means of embankments or terraces and by planting brought out onto the terraces of the structure. This may be formal or informal as the case requires. It is nearly always possible to allow space in the construction for sufficient soil to support planting.

All of the foregoing principals laid down for rural plants hold for urban plants except that in the case of the urban more formality of treatment is usually necessary in order to preserve the harmony of the surroundings.

The aesthetic problems in connection with power substations and transformer stations deserve careful consideration in that these structures are associated with all parts of the region served by power lines. Their location is also more or less fixed by practical requirements. These structures with their outside lace-like steel construction offer picturesque possibilities if they are properly designed and landscaped. If the bare practical necessities only are cared for, the result is a bald unsightly blight on the countryside. There are however many examples of these structures which actually improve the landscape composition. The simplest method of removing their hard appearance is to plant a high clipped hedge around the protecting fence so that the lower part of the structures are masked. The steel structures and intricate, warm colored, insulating apparatus rising out of this green base will often make a composition with the surrounding landscape, interesting and not devoid of beauty.

Your committee, as far as the lack of funds would permit, investigated the various possibilities of improving the aspects of the transmission lines which may be expected to extend eventually to all parts of the country. This investigation seems to point out that three types of transmission lines must be considered, as follows:

(1) Overhead high voltage lines on towers;
(2) Lower voltage lines on poles;
(3) Lower voltage lines underground.

From several competent sources of information of which Exhibits[1] A and B appended to this report are representative, it appears to be impractical to carry higher potentials than 26,400 volts through underground cables. Cable lines carrying 66,000 volts are in use but they are extremely expensive and are still considered as being in the nature of an experiment.

Inasmuch as the scope of power transmission being considered by the Giant Power Survey of Pennsylvania will call for the transmission of potentials of upwards from 110,000 volts, the pole and tower lines must be considered.

The possibility of carrying high voltage lines for short distances through underground cables, as for instance, under roads was considered, but it seems that this procedure greatly increases the danger of the destruction of the line through lightning. The insulation of the cable, although made to resist the line voltage is not heavy enough to resist the high lightning voltage, and the bringing of the line down near the ground tends to attract the lightning. The only way to eliminate this tendency is to install elaborate protection switches and fuses similar to those installed around substations which renders this procedure impractical because of expense.

When a tower high voltage transmission line is run through the country and only the bare practical requirements of the lines are considered, this equipment like any other structure similarly considered offends the eye. The trees in the path of the line are ruthlessly cut down or trimmed with no attempt to preserve their natural symmetry or appearance. The natural growth around the base of the towers is slashed away to make room for workmen putting in the substructure. This method of extending lines is be-

[1]These exhibits may be consulted at the office of the Giant Power Survey.

coming unpopular because of the antagonism it arouses toward the power company.

The proper method of extending power lines calls for the saving of as many trees as possible and the trimming of the remainder under the supervision of a competent forester who has an eye to the preservation of scenic beauty. This supervision should also be extended to cover the future tree trimming necessary to the maintenance of clearances. The bareness of the towers can be overcome by surrounding the lower part with moderately high planting.

The prevalent tendency toward routing these lines without regard to the natural contour of the ground should give way to a more logical routing which would tend toward carrying these lines along existing railroad rights of way or along routes where the least damage to the natural beauty of the countryside would occur. When not confined to roads or other rights of way these lines have been in some cases thrown ruthlessly across unoccupied territory at every angle and every height conceivable although they might have been concentrated for a reasonable distance on adjacent rights of way. An illustration of the deplorable result of such lack of control is shown in the peninsula south of San Francisco, California.

The low voltage lines which will form the most extensive part of the great power system being studied in the Giant Power Survey offers several alternative methods of treatment depending upon the locality through which the lines are extended.

Some of the methods now practised in different parts of the country are objectionable. One involves the ruthless slashing of roadside trees, mentioned above in connection with the high voltage lines. The remedy for the evils of this practice is the same as in the former case. Naturally this results in part from the unstudied placing of the trees, lack of width of highways, and generally in lack of planning of the rural districts.

An objectionable practice encountered on many of our roads today is the erection of a multiplicity of pole lines along a road, electric power, telephone, and telegraph lines,—the result of lack of planning for the future. It should be possible for the Giant Power Survey to include a study of the requirements of the future along the various roads and to produce one pole or at the most two poles which would answer for the combined power line, telephone and telegraph line requirements for a reasonable period of the future.

The prevalent use of the present wooden pole lines will probably have to be continued in some localities, but in the opinion of your committee it seems possible that a webbed concrete pole, similar to those used extensively in Europe and to some extent in this country, could be developed which considering future maintenance would compare in price with the wooden post and which would eliminate the future dilapidated appearance of the pole line extensions.

It is also the opinion of your committee that in some localities conduits could be placed in new concrete roads to provide for low voltage cable lines. Many localities could be served by the ordinary park or suburban cable run through back-filled trenches.

Your committee considered the possibility of studying possible changes in the design of pole and tower equipment which might add to its aesthetic aspect but found that to be effective this study would require extensive experimental work for which no funds were available. It is their opinion, however, that improvements in appearance of many types of equipment could be made which would not add to the expense of this equipment. It has been the experience of the members of your committee that proper aesthetic design is practical design and that many so-called practical designs of structures are often in reality more extravagant of labor and materials than the refined balanced design of the same structure.

Our recommendations for any improvements which are to be brought

about in the aesthetics of the future power transmission developments over those of the past, seem to summarize themselves in their last analysis into one recommendation; that the advice of persons trained in the development of landscape and structural beauty be obtained and considered when these lines are planned, when the equipment is designed, when the lines are extended, and in the supervision of their maintenance.

In closing its report, your committee expresses its great appreciation of the fine spirit and vision of Mr. Morris L. Cooke, through whose invitation the opportunity was given to collaborate with the Giant Power Survey in the public interest.

Respectfully submitted,

SPECIAL COMMITTEE OF THE AMERICAN INSTITUTE OF ARCHITECTS APPOINTED TO COOPERATE WITH THE GIANT POWER SURVEY OF PENNSYLVANIA,

E. H. BENNETT, *Chairman*
HOWARD K. JONES
K. E. MORRISON
DAVID H. MORGAN
CHARLES Z. KLAUDER
JOHN B. HAMME

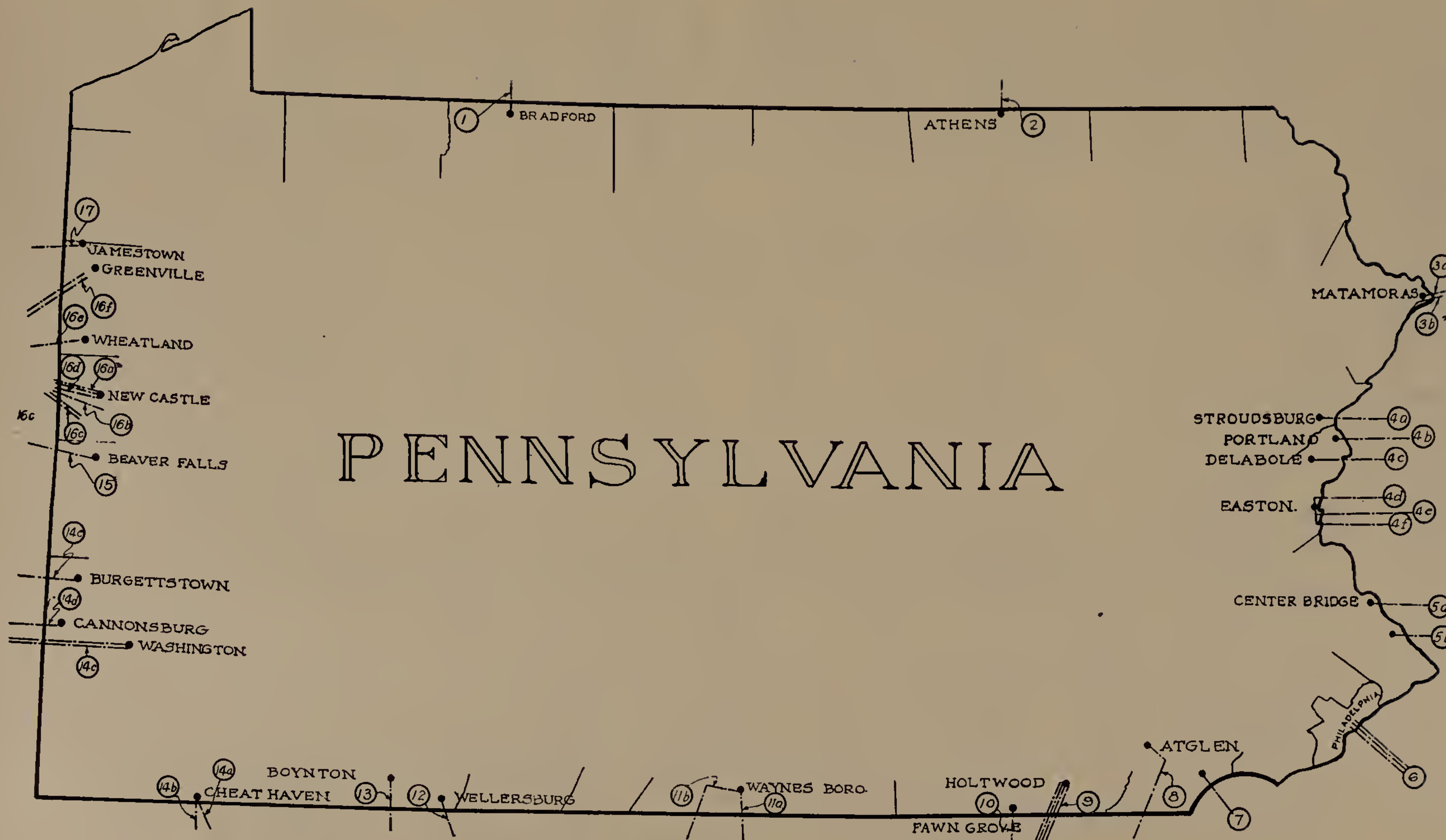

Fig. 1. Map of Points or Locations Where Electric Power Lines Enter or Leave the State of Pennsylvania

THE PUBLIC SERVICE COMMISSION OF THE COMMONWEALTH OF PENNSYLVANIA—

Line No.	Company Name	Approximate Location of Line: Terminal in other State	Enters Pa. in Township of	In County of	Terminal in Pa.
1.	Bradford Electric Co.	Bradford Jt., N. Y.	Foster	McKean	One, two miles within Pa. Another at Bradford
2.	Sayre Electric Co.	Binghamton, N. Y.	Athens	Bradford	Sayre
3a.	Pike County Lt. & Power Co.	Port Jervis, N. Y.	Westfall	Pike	Matamoras
3b.	Orange County Public Service Co. N. Y.	Port Jervis	Westfall	Pike	Milford
4a.	Pennsylvania Edison Co. No. 93	Dunfield, N. J.	Smithfield	Monroe	Stroudsburg, Pa.
4b.	Pennsylvania Edison Co. No. 92	Columbia, N. J.	Upper Mt. Bethel	Northampton	Portland, Pa.
4c.	Pennsylvania Edison Co. No. 13	Columbia, N. J.	Upper Mt. Bethel	Northampton	Delabole, Pa.
4d.	Pennsylvania Edison Co. No. 6	Straw Church, N. J.	Forks	Northampton	Bushkill Park (Easton)
4e.	Pennsylvania Edison Co. No. 23	Green's Bridge, N. J.	Williams	Northampton	Glendin Sub. & South Side Hydro Plant
4f.	Pennsylvania Edison Co. No. 24	Green's Bridge, N. J.	Williams	Northampton	Dock St. Gen. Plant, Easton
5a.	Phila. Sub. Gas & Electric Co.	Stockton, N .J.	Solebury	Bucks	Center Bridge
*5b.	Phila. Sub. Gas & Electric Co.	Washington Crossing, N. J.	Upper Makefield	Bucks	Washington Crossing Bridge
6.	Philadelphia Electric Co. (3 underground cables—2 normally in operation and 1 spare)	Camden, N. J.	Beach St., Phila.	Philadelphia	Philadelphia
7.	Chester County Lt. & Power Co.	Newark, Del.	New Garden	Chester	Kennett Square, Avondale West Grove
8.	Oxford Electric Co.	Sylmar, Md.	West Nottingham	Chester	Nottingham
9.	Pennsylvania Water & Power Co. 4 Circuits—30,000 KVA each	Baltimore, Md.	Peach Bottom	York	Holtwood
10.	Fawn Lt. & Power Co.	Little Deer Creek, Md.	Fawn	York	Fawn Grove
11a-b	Waynesboro Electric Co.	Security, Md.	a Washington b Antrim	Franklin	Waynesboro
12.	Wellersburg Electric Co.	Frostburg, Md.	Southampton	Somerset	Wellersburg
13.	Citizens Lt., Ht. & Power Co. of Meyersdale	Grantsville, Md.	Elk Lick	Somerset	Boynton, Somerset Co.
14a.	West Penn Power Co.	To various Coal Cos. in W. Va.	Springfield	Fayette	Cheat Haven, sub-station
14b.	West Penn Power Co.	State Line to affiliated Co. in W. Va.	Springfield	Fayette	Cheat Haven, sub-station

*Discontinued April 7, 1924.

ELECTRIC TRANSMISSION LINES ACROSS BORDER OF STATE AS OF MARCH 1, 1924.

Line Data				Flow			
Phase	Cycle	Voltage	Capacity KW or KVA	Into Pa.	Out of Pa.	Both	Ownership of Line
3	60	23,000	1,600 KW	—	—	"	Part in Pa., Bradford Electric Company. Part in N. Y., Olean Electric Lt. & Power Co.
3	60	33,000	5,000 KVA	"	—	—	Part in Pa., Sayre Electric Company. Part in N. Y., Binghamton Lt., Ht. & Power Co.
3	60	2,300	250 KVA	"	—	—	Pike County Light & Power Co. Orange County Public Service Co., N. Y. (Affiliated Companies).
3	60	11,000	50 KVA	"	—	—	Frank P. Ludwig—owns from Milford to Matamoras; Orange County Public Service owns from Matamoras to Port Jervis.
3	60	2,300	500 KVA	—	"	—	Pennsylvania Edison Co.
3	60	2,300	1,000 KVA	"	—	—	Pennsylvania Edison Co.
3	60	33,000	4,000 KVA	"	—	—	Pennsylvania Edison Co.
3	60	33,000	6,000 KVA	"	"	"	Pennsylvania Edison Co.
3	60	33,000	10,000 KVA	—	"	—	Pennsylvania Edison Co.
3	60	33,000	10,000 KVA	"	"	"	Pennsylvania Edison Co.
1	60	2,300	37.5 KVA	—	"	—	Phila. Sub. Gas & Electric Co.
1	60	2,300	20 KVA	—	"	—	Phila. Sub. Gas & Elec. Co. and ....
3	60	26,000	12,000 KVA per cable	—	"	—	Philadelphia Elec. Co. to center of River. Public Service Elec. Co. of N. J.
3	60	11,000	500 KW	"	—	—	Chester County Lt. & Power Co. in Pa. Wilmington & Phila. Traction Co. in Delaware.
3	60	11,000	300 KW	—	"	—	Owned or controlled by Oxford Electric Co.
3	25	70.000	4-30,000 KVA			"	Susquehanna Transmission Co. of Penna. Susquehanna Transmission Co. of Md., both subsidiarles of Penna. Water & Power Co.
3	60	2,200	50 KVA	"	—	—	Fawn Light & Power Company.
3	60	33,000	3,000 KVA	"	—	—	One line from Smethburg, Md., to Waynesboro owned by Waynesboro Electric Co. Other line owned from State line to Waynesboro. Connection in Md., owned by Potomac Edison Co.
3	60	6,600		"	—	—	From State Line to Wellersburg by Wellersburg Electric Co. in Md., by Potomac Edison Co.
3	60	6,600	100 KW	—	"	—	Citizens Lt., Ht. & Power Co. of Meyersdale.
3	60	6,600	900 KW	—	"	—	Sub-station owned by West Penn Power Co. lines into W. Va., by an affiliated Co.
		25,000-66,000		—	—	"	Sub-station owned by West Penn Power Co. Lines into W. Va. by an affiliated Company.

THE PUBLIC SERVICE COMMISSION OF THE COMMONWEALTH OF PENNSYLVANIA—

Line No.	Company Name	Approximate Location of Line: Terminal in other State	Enters Pa. in Township of	In County of	Terminal in Pa.
14c.	West Penn Power Co. (Double Circuit)	Windsor, W. Va.	Donegal	Washington	
14d.	West Penn Power Co.	Windsor, W. Va.	Independence	Washington	Avella, Pa.
14e.	West Penn Power Co.	Weirton, W. Va.	Hanover	Washington	Burgettstown
15.	Harmony Electric Co.	Leetonia & Washingtonville, O.	Darlington	Beaver	Morodo Park
16a.	New Castle Electric Co. (Double Circuit)	Lowellsville, Ohio	Mahoning	Lawrence	Various pt. in Mahoning Twp. & New Castle
16b.	New Castle Electric Co.	Lowellsville, Ohio	Mahoning	Lawrence	Various in N. Beaver Twp.
16c.	New Castle Electric Co. (Double Circuit)	Lowellsville, Ohio	Mahoning	Lawrence	Various in N. Beaver Twp.
16d.	Pennsylvania Power Co.	Lowellsville, Ohio	Mahoning	Lawrence	New Castle
16e.	Shenango Valley Elec. Lt. Co.	Masury, Ohio	Hickory	Mercer	Wheatland
16f.	Shenango Valley Elec. Lt. Co. (Double Circuit)	Masury, Ohio	Hickory	Mercer	Sharon and other sub-sta.
17.	Mercer County Lt., Ht. & Power Co.	Kinsman, Ohio	Greene	Mercer	Jamestown, Pa.

IV. WATER SUPPLY AS A FACTOR INFLUENCING THE LOCATION OF GIANT POWER PLANTS

BY AUGUST ULMANN, JR.
Mechanical Engineering Dept., University of Pennsylvania

One of the great objections that has been raised in the consideration of Giant Power plants located at or near the mine mouth is that very few mines are located near rivers large enough to furnish the water required. In the most approved modern power plant practice, water is almost as important an element as the fuel because the high efficiency now obtained in the changing of heat energy into electrical energy is entirely dependent upon large and adequate supplies of cool water. In the case of the power plants of ocean liners, which were the giants of previous days, the space occupied by the coal is so valuable, and the cost of the coal itself so high, that the utmost economy in its use has been a well developed art for a good many years. But, as the whole ocean is available as a water supply, the question of the cost of the water does not enter into the problem.

In the early years of the art of power generation on land, coal was not costly, and the question of fuel economy was not so urgent. The cost of the

ELECTRIC TRANSMISSION LINES ACROSS BORDER OF STATE AS OF MARCH 1, 1924.—Concl'd

Line Data				Flow			
Phase	Cycle	Voltage	Capacity KW or KVA	Into Pa.	Out of Pa.	Both	Ownership of Line
3	60	132,000	50,000 KW	"	—	—	West Penn Power Company.
3	60	25,000	500 KW	"	—	—	West Penn Power Company.
			(10,000 KW)				West Penn Power Company.
3	60	25,000	4,000 KW	—	—	"	West Penn Power Company, and by an affiliated company.
			(15,000 KW)				
3	60	2.300	1,472 KVA	—	"	—	Part in Pa. by Harmony Electric Company. Part in Ohio by Ohio-Harmony Electric Co. Both controlled through parent companies which in turn are controlled by Pittsburgh, Butler & Harmony Consolidated Rwy. & Power Co.
3	60	2.200	2,600 KVA	"	—	—	New Castle Electric Co. in Pa. Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	66,000	20,000 KVA	"	—	—	New Castle Electric Co. in Pa. Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	22,000	4,000 KVA	"	—	—	New Castle Electric Co. in Pa. Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	66,000	9,200 KVA	"	—	—	Pennsylvania Power Company. Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	22,000	2,200 KVA	"	—	—	Shenango Valley Electric Light Co. in Pennsylvania. Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	22,000	6,000 KVA	"	—	—	Shenango Valley Electric Light Co. in Pennsylvania.
		22,000	8,500 KVA				Pennsylvania-Ohio Power & Light Co. in Ohio.
3	60	6,600	150	—	"	—	In Pennsylvania, Mercer County Lt., Ht. & Power Co. In Ohio, Kinsman Electric Co.

fuel was a relatively small proportion of the total cost of operation and it was well known that maximum thermal efficiency did not always produce the lowest cost of power. A great deal of labor had to be employed in the older type plants and labor saving was then the most telling economy.

Great strides were made in the saving of labor in power plants by the invention of the automatic stoker and the development of coal handling devices, motor operated valves and many other important and ingenious improvements both mechanical and electrical. The cost of fuel thus came to take precedence, and economy in its use became the paramount problem. In addition, the rapid rise in the cost of fuel accentuated the importance of its economical use.

Steam Expansion and Improvements

Thus attention was directed to an effort to increase the thermal efficiency of all the elements of the power plant. Boilers were improved, steam pressures raised, superheaters and economizers were added and the science of combustion was studied minutely and to great advantage. The greatest development of all was the advent of the steam turbine and its rapid strides toward perfection. It reduced the cost of buildings on account of the small space it occupied, was found to be reliable and rugged and on account of the

fortunate features of its design it was possible to make use of that great range of the expansion of steam that takes place in the pressures below that of the atmosphere. This gave rise to the rapid development of the condenser by means of which this great source of additional thermal efficiency is made available. The condenser is one of the oldest parts of the power plant, but due to the constructional difficulties encountered in the older type of engine equipment, which made very expensive the utilization of the whole of the possible expansion of steam in the pressures below atmosphere, its ultimate development was postponed until the advent of the turbine and the high cost of fuel.

It is the operation of the condensing equipment that requires the large quantities of cool water that are essential to a modern power plant. In order to produce the lowest terminal pressure of steam expansion possible all the time, about 90 pounds of water must be pumped to condense each pound of steam. This is common practice today and is the factor that necessitates locating a large power plant near an adequate body of water. In older practice, before the advent of the turbine when it was considered ample to expand steam to one pound per square inch absolute pressure, 20 to 65 pounds of water were required to condense one pound of steam and the average for a year's operation was only about 35 pounds of water per pound of steam, about 39 per cent. of present requirements.

Present practice, due to the high cost of coal, high fixed charges due to expensive equipment, and comparatively low labor and maintenance costs, finds that the lowest cost of power coincides with maximum thermal efficiency.

Giant Power Plants

Now comes the further development of the Giant Power chain of plants. High transportation cost of coal is forcing the plants away from the large bodies of water into the interior right to the mouth of the mine. The cost of fuel will go down. It will at least be cut in two and may perhaps be cheaper. The influence of the cost of fuel on the cost of power will be reduced and we shall return to old practice in that the lowest cost of power may not coincide with maximum thermal efficiency. Also the water requirements of the well-designed Giant Power plant will probably be much less than present day practice demands.

This has been recognized by a good many engineers and one man of broad vision has even suggested the other extreme and proposed doing away with the condensing requirement and designing the Giant Power plants to operate non-condensing.

In order to fully visualize all the elements of the problem, a calculation was made to predict as nearly as possible on the basis of plants recently constructed, the costs of operation of various plants designed to operate at various pressures below atmospheric and with various costs of coal. This was done in order to predict approximately just what degree of thermal efficiency may coincide with the lowest cost of power for any cost of coal. Some of the elements of this calculation and its final results are shown in order to substantiate the statements previously made.

It must be borne in mind, however, that the cost of construction of the

Giant Power plants will probably be materially lower than those used in this calculation for the following reasons: Existing plants are nearly all built in or near large cities where real estate values are high and buildings are expensive due to labor and material costs and the emphasis at present placed on architectual features.

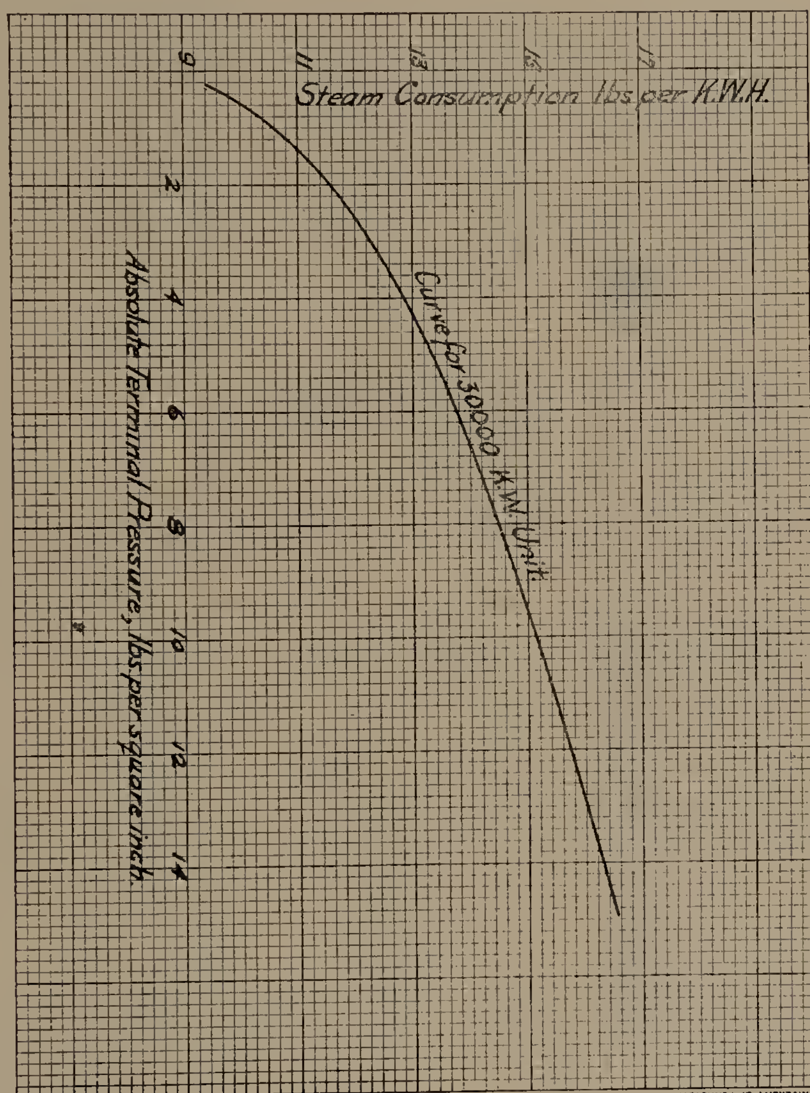

FIG. 1. STEAM CONSUMPTIONS OF THE MODERN TURBO GENERATOR UNIT

Figure 1 is a graph which shows the increase of steam consumption of the steam turbine as the terminal or back pressure increases. The lowest possible terminal pressure known to present practice is about one-fourth of a pound per square inch absolute and can be obtained during the winter months only when the temperature of river waters is 37° or lower. As the

terminal pressures increase the steam consumption per kwh. increases rapidly until at atmospheric pressure the steam consumption is 74.5 per cent. greater than 9.4 pounds of steam per kwh., corresponding to the lowest terminal pressure.

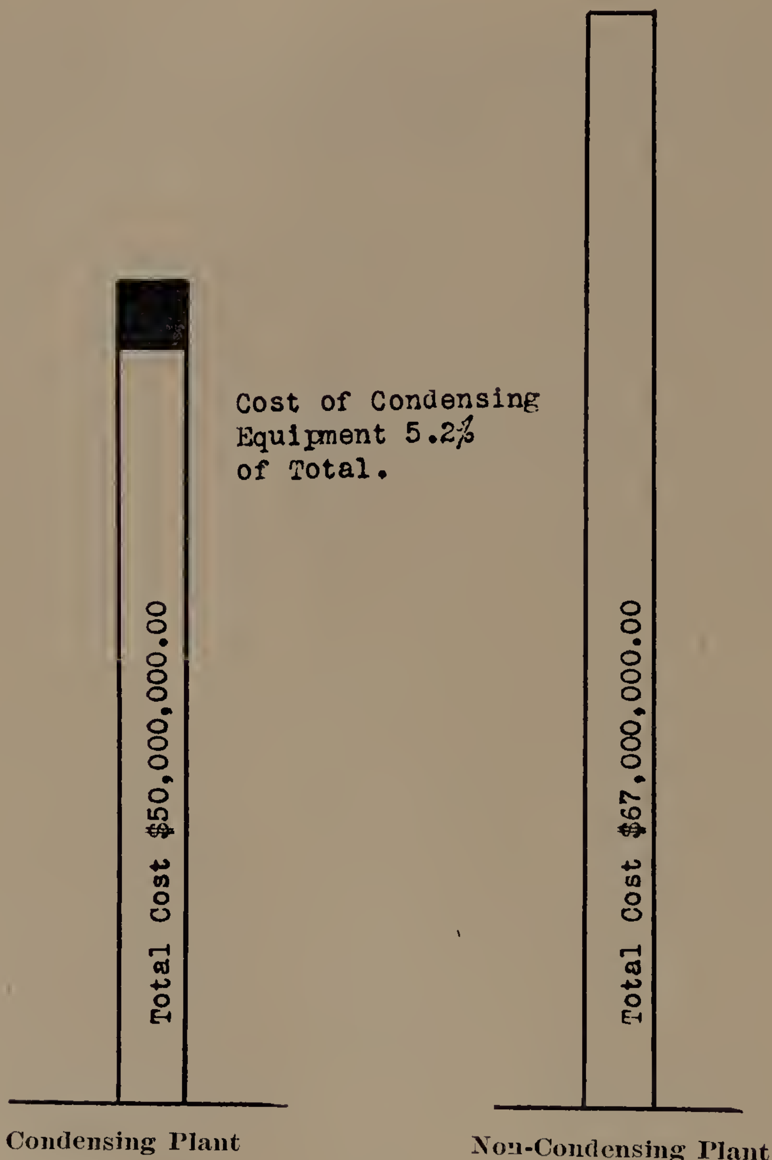

FIG. 2. COMPARISON OF COSTS OF CONDENSING AND NON-CONDENSING PLANTS OF 500,000 KW. CAPACITY

By the expenditure of $2,600,000.00 in Condensing Equipment, $17,000,000.00 are saved in the cost of the plant.

If the condensing equipment is omitted entirely so that the terminal pressure becomes atmospheric, 74.5 per cent. more boiler and coal equipment must be provided at enormous expense and an equal percentage of additional coal must be burned. However, if the condensing equipment be modified slightly to maintain say a terminal pressure of one pound per square inch absolute, the steam consumption increases only about 10 per cent. and the cost of the plant is not materially affected, as the slight additional cost for slightly larger boilers is offset by the reduced cost of the condensing equipment.

In Table I, is shown the different predicted costs of Giant Power plants designed for various terminal pressures. In speaking of the per cent. increase of cost, the figures do not convey much meaning, but when actual total figures are considered the differences become staggering.

The comparison shown in Figure 2, conveys to the mind very vividly just how important a part the condenser takes in the make-up of the modern power plant. It cannot safely be thrown aside for three reasons:

(1) Capital expenditure must be conserved;

(2) Coal reserves must be conserved;

(3) Costs of power must be kept at the absolute minimum.

The condenser is the safeguard against the violation of these three principles.

Turning again to Table I, it is noted that the least expensive plant is that which corresponds to operation at one pound per square inch absolute terminal pressure, which indicates the possibility that with this plant may be obtained the lowest cost of power.

In Figure 3, is shown a family of graphs which are the result of a careful analysis of the costs of operation in the seven hypothetical plants indicated in Table I. Horizontally are plotted terminal or back pressures and vertically the resulting costs of power in cents per kwh. Each graph corresponds as indicated to a different cost of coal. These graphs bear out the statement previously made that the lowest cost of power may or may not coincide with maximum thermal efficiency. The graph for $6.00 coal is representative of present day practice and it confirms accepted designs of today in that the lowest terminal pressures are sought after because the least terminal pressure shows the lowest power cost.

TABLE I

(Costs of building the 500,000 kw. Giant Power plant designed for various absolute terminal pressures of steam expansion. Unit costs have been taken from plants actually constructed.)

Absolute terminal pressure lbs. per sq. in.	*Cost per kw. of installed capacity*	*Net output in kwh. per year*	*Total cost of plant*
Least possible	$100.00	1,650,500,000	$50,000,000.00
1	99.00	1,681,050,000	49,500,000.00
2	99.50	1,685,465,000	49,750,000.00
4	110.00	1,686,878,000	55,000,000.00
7	122.50	1,687,523,000	61,250,000.00
10	125.50	1,687,773,000	62,750,000.00
14.7 (Atmosphere)	134.00	1,691,000,000	67,000,000.00

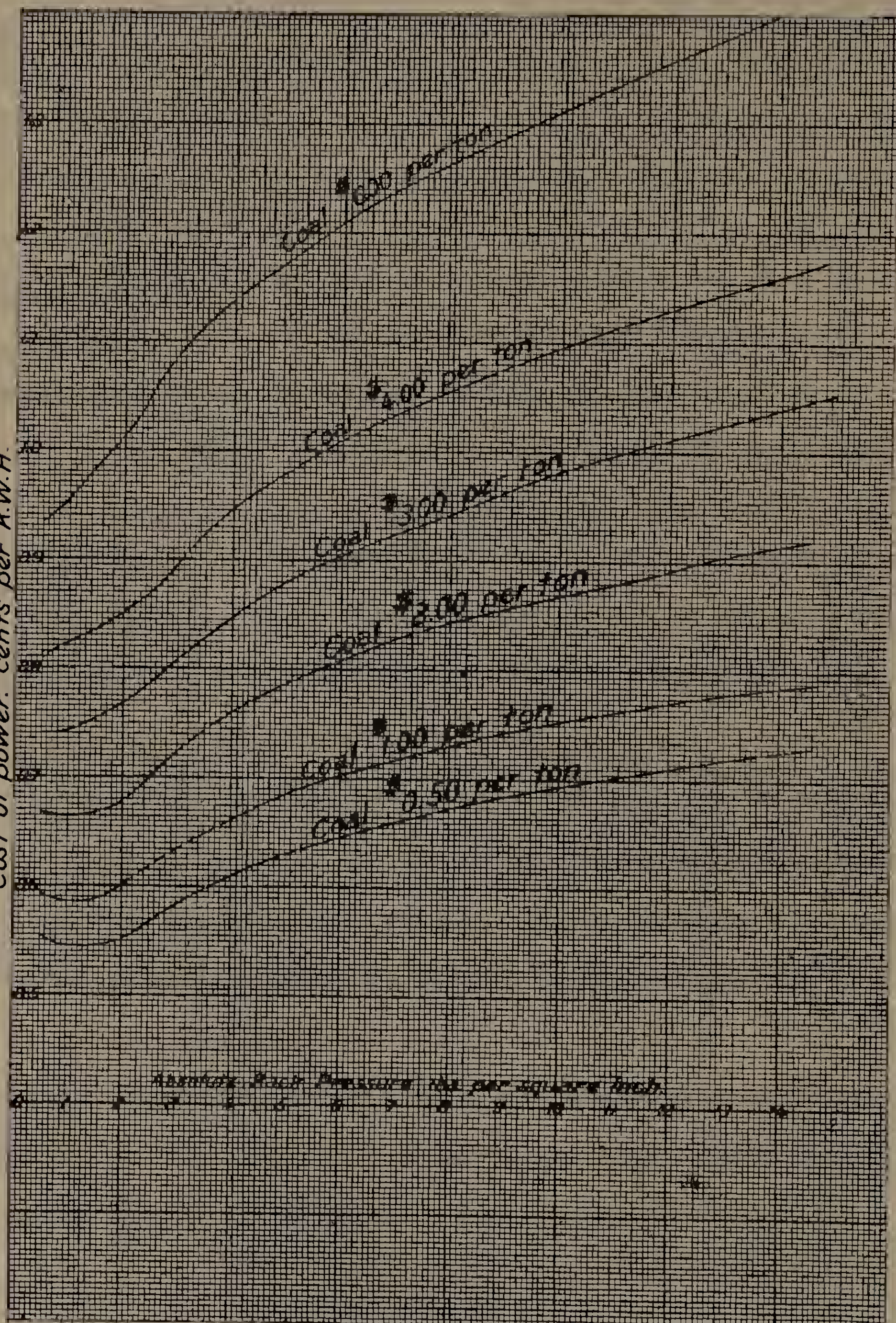

FIG. 3. VARIATION OF COST OF POWER WITH THERMAL BACK PRESSURE AND PRICE OF COAL

The Giant Power plants will operate in the region lying below the graph for $2.00 coal. In this region as the terminal pressures increase the cost of power first decreases slightly and then increases rapidly. The least cost of power corresponds nearly to the terminal pressure of 1 lb. per square inch absolute.

COMPARISON OF COSTS OF OPERATION OF CONDENSING AND NON-CONDENSING PLANTS OF 500,000 KW. CAPACITY

Coal 13,000 btu's. at $2.00 per ton. Capacity Factor 40%. Back Pressure 1 lb. per sq. in. abs.

Cost of operation of Condensing Equipment 4% of Total.

By the use of condensing equipment $4,428,000.00 is saved each year in the operation of the plant

CONDENSING PLANT
Cost of Operation per year= $11,134,000.00
Net kwh. Output=1,681,050,000
Cost of Power=0.663¢ per kwh.

NON-CONDENSING PLANT
Cost of Operation per year= $15,562,000.00
Net kwh. Output=1,691,000,000
Cost of Power=0.92¢ per kwh.

FIG. 4

There is also a probability that the operation of these plants may be thrown into the region below the graph for $1.00 coal if by-product recovery be practiced. The value of the by-products may very well be so great as to make the cost of the coal residue almost negligible. In this case the graph for the cost of power becomes so flat that the plant would show excellent economy if operated from two to five pounds per square inch absolute terminal pressure.

Figure 4 shows a comparison of the costs of operation for the condensing and non-condensing plant. Again the difference in totals is staggering.

It appears then that one of the greatest controlling factors in the successful accomplishment of the Giant Power idea is the question of water supply. As pointed out in Mr. F. H. Newell's report on "Pennsylvania's Natural Re-

sources Available for Power," this State is well endowed with rivers which flow through or near the coal fields.
the rivers. The chart, Fig. 5, shows in the large shaded area the average water large enough to be above question as to their ability to support the operation of a Giant Power plant. In order to determine their usefulness it is necessary to compare their seasonal flows with the water demand of the Giant Power plant. There is one element that must be considered first that has a great effect on the water demand of the Power Plant and that is that the temperatures of the river waters vary considerably during the year.

These temperatures vary as shown in the following table.

Average Temperature	*Months Duration*
40° or less	3 months
50°	3 months
60°	2.4 months
70°	2.4 months
75°	1.2 months

Such variations cause the water demand of the plant to increase considerably in the summer which, unfortunately is the time of minimum flow of the rivers. The chart. Fig. 5, shows in the large shaded area the average water demand for a plant designed to operate with a terminal pressure of 1 lb. per square inch absolute. The small narrow shaded areas simply show the maximum which is needed for a short time each day to meet the requirements of the morning and evening peak loads. First compare this with the area included within the dotted lines which indicates the demand for a plant as operated to maintain the lowest possible terminal pressure. The difference in the amount of water required is enormous and indicates clearly how a little modification of present practice will benefit the water situation as well as to insure the lowest cost of power.

On the right side of the chart are shown the various flows of four of the principal rivers of the state. From the location of the flow marks corresponding to the second feet vertical scale of the chart and with reference to the shaded area at the bottom a very good idea of the availability of these rivers for the support of a Giant Power plant may be obtained. These flows are taken from Mr. F. H. Newell's report and correspond to sites chosen as convenient for the location of a Giant Plant. These sites do not avoid entirely the hauling of coal by rail to the plant but in every case they reduce the haul to thirty miles or less. Further, it is likely that these sites will make available inferior veins of coal that it does not pay at present to mine and ship.

In considering each of these rivers in detail with reference to the power plant, the Monongahela should be considered first. This river has already been provided with flood regulation dams which have steadied the flow of the river so that its summer flow is steady at 1500 second feet. A small dam and spillway at the plant will impound sufficient water to care for the few summer days when the demand of the plant exceeds the flow of the river for a few hours. The average flow of the river is so far in excess of the plant demand that the resulting heating of the water will not be serious to those industries located below the plant.

The Susquehanna River is so large that there will be no need of any but the most nominal provision for impounding summer flow in order to insure meeting properly the daily plant maximum demands.

The Allegheny River has a minimum summer flow somewhat lower than the maximum demands of the Giant Plant. But as its average summer flow

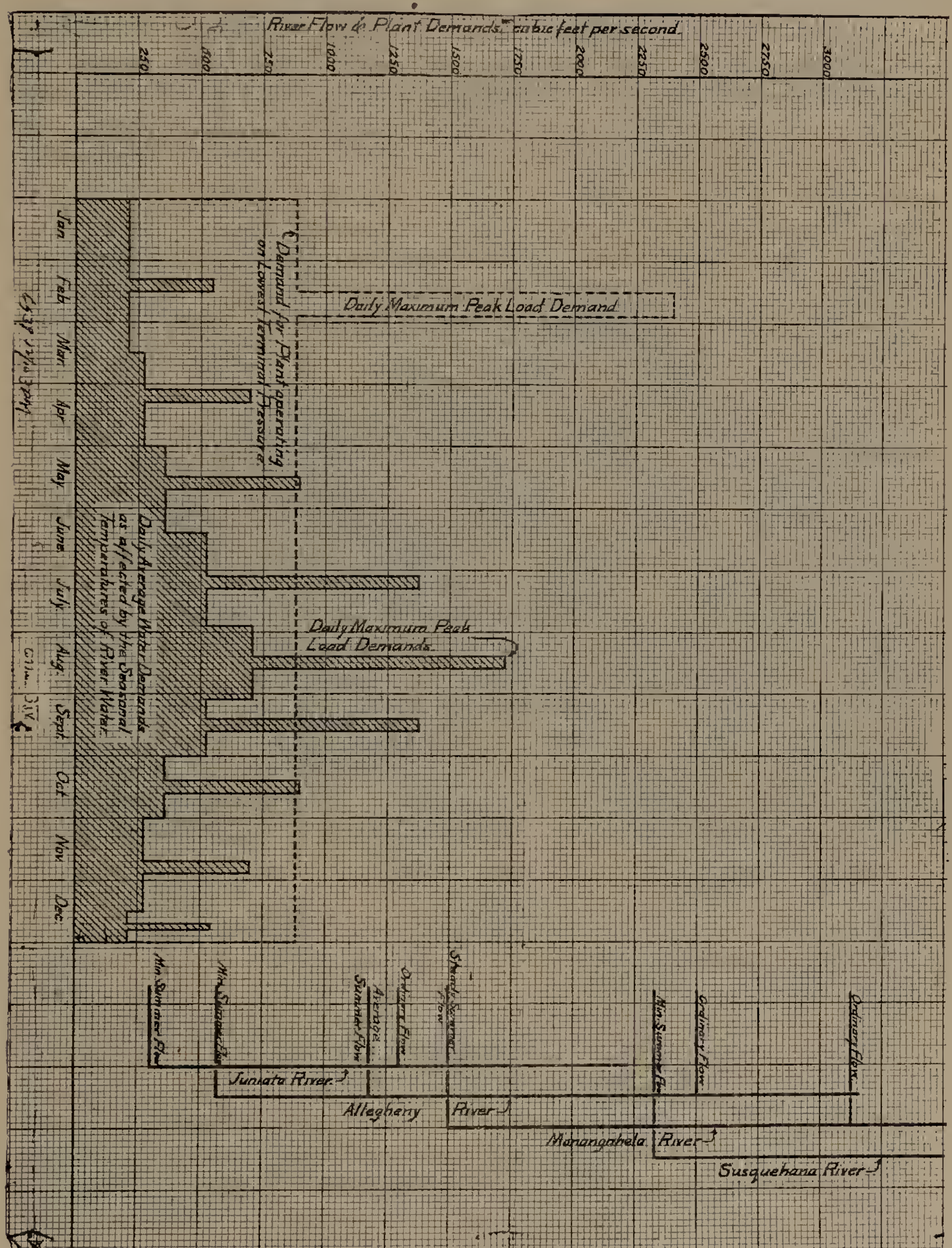

FIG. 5. DAILY AVAILABLE WATER DEMANDS AS AFFECTED BY SEASONAL TEMPERATURE OF RIVER WATER

is greater than the maximum demand, there should be no great expense entailed in the constructions necessary to insure an adequate water supply the year round for a large power plant. Flood regulation on this river should be a great boon to the communities located along its banks as the flood flow often exceeds one hundred times the ordinary flow of 2500 sec. ft.

The Juniata River is a much smaller stream but is capable of development into a stream fully capable of supporting the demands of a Giant Plant. Its minimum summer flow is considerably below the demands of a Giant Power station so that correspondingly more expense would be entailed in its development into a fully useful stream. But as this development would serve two purposes i. e.: Flood regulation; and the supplying of a Giant Plant, the cost of power need not be increased by the full amount of the fixed charges on the capital outlay.

The flow of the Ohio River comprising the waters of the Allegheny and Monongahela and their tributaries is large enough to support the water demands of a Giant Plant with no extra expense entailed further than adequate suction bays and discharge tunnels so arranged as to meet the greatly varying level of the river.

These larger rivers are adequate and without doubt can be made to serve the demands made by a Giant Plant. There are, however, several other smaller rivers of a minimum summer flow of 300 second feet or less that can, if necessity demands it, be made to serve also. There are means now available for cooling condenser circulating water which while quite expensive to install are not at all costly to maintain and operate. The principle expense of operation is the extra pumping of the whole quantity of water circulated. In all cases the cooling is done without cost by exposure of the water by one means or another to the outside air.

Where a river is nearly adequate the cooling installation may be so designed as to care for the water deficiency only and very often it may be possible to confine its operation to the summer months.

One very ingenious method of accomplishing this cooling is by reversing part of the flow of the river. A dam is built at the plant with two spillways, one higher than the other. Then two channels are dug or dredged in the river bed, one on each side, and the material dredged is piled up between the two channels so that a long dam is formed separating one from the other. This dam entails no extraordinary expense in construction as the water levels on each side of it will be nearly equal. An island or chain of islands may be used as part of this dam. It may be necessary as occasion demands, to make this separation of the channels a mile or more in length. The condenser circulating water is pumped from the lower spillway through the condensers and then discharged into the higher spillway and made to flow up the river the length of the central dam and cool itself and finally turn the end of the dam and return to the lower spillway. During times of adequate water, the pumps can be shut off and the power for pumping saved. During floods both spillways will care for the excess water and discharge it into the lower river bed.

No existing instance of this particular system of cooling can be cited.

However, the Hauto Plant of the Pennsylvania Power and Light Company utilizes a canal, fifteen feet wide and five feet deep by 2000 feet long for this purpose. As the plant is of 60,000 kw. installed capacity it can be seen that the construction cost of this part of the equipment should not be excessive.

There are no installations of cooling towers for condenser water in the State of Pennsylvania comparable in size or modern construction to those found in European practice.[1] In Europe the power plant at the mouth of the mine is already an accepted fact and in the development of the locations it has been found advantageous in some cases to abandon adequate water in order to shorten the railroad haul of the coal. This is true of the Municipal Plant of the City of Birmingham, England, where adequate water exists only

FIG. 6. COOLING TOWER INSTALLATION OF THE NECHELL'S PLANT OF THE MUNICIPALITY OF BIRMINGHAM, ENGLAND

twenty miles distant from the site chosen for the plant. The plant is of 110,000 kw. installed capacity and has a complete condenser water cooling system of 48 large cooling towers built over a concrete reservoir. Fig 6 is a photograph of this installation showing very graphically the proportions of these towers.

The following data in regard to this installation is of great interest as it indicates the possibilities of much larger projects.

[1]Details given as to these installations were obtained in England and Germany by a representative of the Giant Power Survey through introductions arranged by the State Department. The Survey is indebted to Secretary Hughes and numerous public officials and representatives of private interests abroad for courtesies and special opportunities for observing on the ground these and other developments in the electrical field.—*M. L. C.*

1. 48 Wood and Steel Towers, each 90 ft. long and 30 ft. wide at the base by 110 feet high.
2. Steam consumption of the plant 12 lbs. of steam per kwh.
3. 80 lbs. of circulating water are cooled per lb. of steam condensed.
4. 1.6 square feet of cooling surface per kw. of installed plant capacity.
5. The cooling water temperatures are 95° F. going into the towers and 75° F. after cooling.
6. Air conditions at which the towers are rated are 65° F. and 85 per cent. relative humidity.

FIG. 7. COOLING TOWER INSTALLATION OF THE ZSCHORNEWITZ PLANT OF THE ELECTROWERKE A. G. AT GOLPA, GERMANY

7. The evaporation loss of circulating water in the towers is about 1 gallon per kwh. or roughly one per cent.

One of the most novel features of this installation is the fact that the water used for circulating water is the discharge from the Birmingham Sewage Purification System. This is of great advantage as the water is soft, absolutely free of mud and silt and can be maintained very uniform in quality. This clean water has two great advantages in that first it has very little deleterious action on the materials of the cooling towers, reducing their maintenance to almost nothing, and secondly clean, pure water makes it possible to operate the condensers almost indefinitely without shut down for cleaning.

Plants located on such bodies of water as the Delaware River, Hudson River, New York Bay, Ohio River, Mississippi River, etc., can run a condenser only four to seven days without cleaning.

Fig. 7 shows the cooling tower installation of the Zschornewitz Plant of the Electrowerke A. G. at Golpa, Germany. The plant is of 130,000 kw. capacity and there are sixteen cooling towers of steel and wood each capable of cooling 133,000 cubic feet of water per hour. The lift of the pumps that handle this water is 35 feet.

At this plant particularly pure clean water is available so that the maintenance of the towers is negligible and from present indications they will last indefinitely. The condensers are run for very long periods without cleaning. The records show that turbine units have been in service continuously for three years without a shut down for condenser cleaning.

The modern large turbo unit of 30,000 to 70,000 kw. capacity is a very sensitive machine. At present, steam temperatures of 650° F. are quite common and very much higher temperatures are proposed as steam pressures of 1200 lbs. per square inch are being considered. Materials subjected to such high temperatures suffer greatly when these temperatures are changed often. The rapid changes of temperature and the radical changes of stresses due to starting and stopping these machines are one of the chief sources of wear and tear and cause the greatest depreciation. Thus, if one of these machines can go into uninterrupted service for a very long period, as these units at Zschornewitz, the resulting saving in maintenance on the prime movers will go a long way toward paying the extra expense due to the operation of the cooling towers.

The last word in cooling tower construction is being built at Trattendorf, Germany, at another plant of the Electrowerke A. G. This tower is of 25,000 kw. capacity and is built entirely of reinforced concrete and tile. The illustration on page 32 (see Director's Report) gives a remarkably fine view of the construction. Fig 8 is a view of the concrete and tile cooling unit on the inside at the base of the tower. This unit is about thirteen feet high and is located in the base of the tower and consists of a number of transverse concrete troughs which deliver the water to smaller perforated troughs. The water flows through the perforations and is broken up into a thin film by a tile checker work below, through which the cooling air flows upward. The remainder of the height of the tower is simply a chimney which by means of its natural draft furnishes the required air for cooling.

This plant has an installed capacity of 82,000 kw. and there is a river flow available that is adequate for the condensing of the steam from 60,000 kw. capacity. The concrete cooling tower is being installed to take care of the deficit of 22,000 kw. The general dimensions of this cooling tower are as follows:

The base of the tower containing the cooling unit is 78′ 6″ square and the upper part is 72 ft. in diameter, the height of the whole tower being 150′ 0″. The lift of the pumps delivering the water to the tower is 49′ 0″ and the cost of the entire tower is estimated to be about 150,000 marks.

Another method widely employed for cooling condenser circulating water

is the Spray Pond. The water is pumped through a net work of pipes and is discharged in a fine spray from specially designed nozzles. The water is cooled as it passes through the air and is caught in a shallow concrete pond which occupies the entire area under the piping. This method is very efficient but is somewhat more costly as the ponds are expensive to build and a higher pumping head is usually involved to force the water out of the nozzles. But there are cases where a small dam in a river will furnish the pond at little expense and the sprays can be located on the banks of the pond so formed. An installation of this type is found at Waterbury, Conn., at the plant of the Connecticut Light and Power Company.

FIG. 8. CONCRETE AND TILE COOLING UNIT OF THE CONCRETE COOLING TOWER AT TRATTENDORF

The Spray Pond is a distinctly American development. One manufacturer of spray nozzles reports that his product is being used in 1,495 ponds scattered over these United States and twenty-four foreign countries which fact gives excellent proof of the popularity and success of this system.

The Spray Pond installation at the Pine Grove Plant of the Penn Electric Company near Pottsville, Pa., is the largest installation of its kind in the world and has a cooling capacity of 57,600 gallons per minute sufficient to care for the circulating water required for 30,000 kw. of installed generating capacity.

The general impression gained from a review of these installations is that they have proved to be a distinct success as they have apparently passed

considerably beyond the experimental stage. The concrete tower is the only one that may be considered as doubtful but as the principles involved in its construction are sound beyond question it may be accepted as a distinct advance in the art.

With this advance in the art of cooling circulating water the choice of the location of the Giant Plant may very well be found to be entirely independent of adequate rivers. The cost of the development of a moderate stream to furnish all the circulating water required by a Giant Plant can easily exceed the cost of a cooling tower installation to take care of the

Fig. 9. Showing Cooling Tower at the Hirschfelde Plant, Germany, 20,000 kw. Capacity

whole or a part of the circulating water required. Even if there should appear no difference in the cost of the two installations, the added advantages obtained in the general operating conditions of the plant might easily swing the choice to the providing of an artificial cooling system.

In concluding it is pointed out that in as much as the Giant Power System will be a radical change in our present power plant practice it is necessary to broaden our viewpoint and in the design of the Giant Plant, prejudices, bred by the practice of today, must be smothered. The calculations and facts contained in this part of the report are presented not altogether as being a solution but as suggestions for future detailed and minute

analyses of plant locations proposed. In Europe we see that water shortage has no terrors for the power plant designer, and that locations at the mine mouth have been developed regardless of this apparent disadvantage. The fact that cheaper coal will be an assured fact must be recognized and our viewpoint revolutionized accordingly.

The State of Pennsylvania is well endowed with rivers both large and small so that a very wide range of locations is available, and it may not be found necessary to resort to artificial cooling of water in any but the most extraordinary circumstances. However, this recourse is at our disposal and there need be no hesitation in considering it as it has already been developed to proportions approximating the Giant Plant conception.

V. MEMORANDUM ON LOAD FACTOR

by

O. M. RAU, *Consulting Engineer*

The period of use of equipment representing capital investment, broadly stated, is an index as to the profitableness of an enterprise. This is expressed as "Load Factor" in the electric power industry.

A Giant Power System must operate with the highest load factor attainable to discourage the construction of small and local power generating plants.

One of the largest items constituting total power cost is the so-called fixed charges, which include all expenses not chargeable to operation. Unlike operating expenses, fixed charges are more or less constant irrespective of the amount of power generated. For the central station supplying power to a local system, these charges approximate one-half the whole cost of electric power production.

Fixed charges consist principally of fair return, depreciation and taxes, all of which are directly proportioned to capital invested. Assuming as a fairly representative figure an investment of $100 per kw. of plant capacity (based on the total number of units at manufacturing rating) and 15 per cent. per annum as more than sufficient to cover all the items included in fixed charges, the amount representing this part of the cost of producing a kwh. (which is exclusive of operating expenses) will depend on the number of kwh. the plant generates during a year. The plant having a definite capacity will be dependent upon the ratio of the average load to such capacity to obtain the proportionate cost per kwh. of the fixed charges.

The average use for electric power from a local plant is well above eight hours per day of the capacity of the station equipment required to generate the maximum load. This gives a load factor of over 30 per cent. A local plant, however, requires sufficient capacity over and above that required to carry the maximum load to assure reliable and continuous service. It is therefore apparent that the capacity actually used to generate the power may have a load factor in excess of 30 per cent. The capacity of plant

equipment on which fixed charges must be paid, however, will be less than 30 per cent.

It therefore appears that as the fixed charges are arrived at from the cost of the plant, the factor affecting these costs should be based on capacity rather than load. This suggests that the capacity factor should be used in place of the load factor. To carry a given load the capacity of a plant requires equipment in excess of that capable of generating the load. The amount of such excess capacity which should be provided is generally dependent on the size of the individual units in the plant. Conservatively stated this additional equipment should have a capacity equal to the largest unit in the plant. Such extra equipment within reasonable limits, however, need only be provided in one plant where a number of power sources are connected to one system, as this extra capacity becomes available for all the plants furnishing power to the same system.

It is therefore, difficult to use capacity factor as a measure or unit except in its broad application to a system as a whole, where the total capacity of all the power plants can be considered as one power source.

The growing tendency to establish interconnection not only between power plants of one system but also between different systems so as to make available spare capacity for emergency use practically eliminates the need of providing station capacity beyond that required to generate the maximum load of the plant. Not only is any unit, not in use on the interconnected system, available for an emergency, but the overload capacity of each generator on the system is also available which in the aggregate will more than be sufficient for any emergency which could be reasonably anticipated.

In referring to Giant Power Plants the capacity factor and the load factor become the same as the maximum load of these plants is limited to the capacity of the generating equipment. No consideration, therefore, need be given to spare equipment. Therefore, the annual load factor of any one point becomes the ratio of the average load to the maximum load which is approximately the plant capacity.

The average load factor for the State of Pennsylvania is estimated to be in excess of 40 per cent. Plants operating in a diversified industrial district such as in the eastern part of the State will range from 40 to 50 per cent. Plants supplying power to the glass and steel industries in the western part of the State have a load factor ranging from 60 to 70 per cent., while in agricultural and commercial districts the range may be from 20 to 30 per cent.

With trunk transmission lines making it possible to take advantage of the diversity of these various sectional activities, in addition to the variation of one hour in time between the eastern and western part of the State, a load factor considerably in excess of the average will be obtained.

Conservatively estimating a load factor of 60 per cent. as readily obtainable for a Giant Power plant, the fixed charges per kwh. from a Giant Power source will be considerably lower than those of a system which cannot obtain the diversity of State wide integration, and the advantages of utilizing the full capacity of plant equipment.

The effects of load factor on the operating costs of an electric power

plant are well known and are quite comparable wtih manufacturing plants in other industries.

The reduction in operating expenses when equipment can be operated at its economic load over long periods needs no detailed analysis. There are, however, advantages in operating power plant equipment continuously, not usually found with other classes of apparatus. This pertains particularly to maintenance expense of boilers and turbines, to which temperatures are of vital importance. The operation of such equipment at constant load maintains an even temperature avoiding the dangerous stresses such equipment is subjected to when operating with varying loads. This results in reduced maintenance expense as well as increased reliability.

The load factor, therefore, becomes the key to low cost power from Giant Power plants, first in reducing fixed charges, second in effecting operating economies and third in increasing the reliability of the equipment.

The experience of European engineers is of particular interest in this connection. Instances are on record of turbo-generators regulated by temperature readings of thermometers located at critical points, which resulted in their continuous operation for three year periods without a moment's interruption. These turbo-generators are located in base load plants the annual load factor of which reaches as high as 93 per cent.

VI. CONSOLIDATION IN ELECTRIC UTILITY INDUSTRY[1]

AN ANALOGY BETWEEN CONSOLIDATION OF RAILROADS AND OF ELECTRIC UTILITIES

BY JOHN L. STEWART

Member Pennsylvania Public Service Commission

It is generally recognized today that the fundamental and underlying principle of public utility operation is the exercising of monopoly power under adequate and effective government regulation. It is evident that any benefits which might result from unrestrained competion, involving duplication of facilities used in rendering a public service, would be wholly destroyed by the economic waste which such duplication involves. This concept is not the product of abstract theorizing but of years of national and state experience with railroad and public utility enterprises. The form of monopoly which is objectionable is that which results from a uniting of organizations for the purpose of restricting output, increasing prices and engaging in unfair methods against consumers and other producers.

The granting to a certain organization of the exclusive right to render a given kind of public utility service in a limited territory carries with it inherent evils. There is always a danger that the utility will abuse its privileges to the public detriment. These possibilities of evil are held in check, however, by an alert and intelligent public interest, and by a public

[1]Quoted by permission from an article to appear in the annals of the American Academy of Political and Social Science, March 1925.

service commission duly constituted and empowered to require adequate and sufficient service at fair rates. There must be an understanding of the fact that railroads and utilities must be controlled for the protection of one another and of the public.

The early concept of government relations with organizations supplying public service was that competition is desirable and should be enforced if possible. This became the basis of action with respect to railroads, until comparatively recent years, when it became partially realized that they are by nature monopolies and form a distinct type of private enterprise. There remained, however, a large element of fear that railroads would combine to the injury of the public.

Beginning about 1870, when railroad competition became active, there was a cutting of rates and discrimination against non-competitive points which rapidly led to a demoralization of railroads. Bitter rate wars were waged, and it soon became evident that, if the unrestrained competition were continued, the roads would be plunged into bankruptcy and hopeless ruin, with disastrous consequences to towns and cities, as well. The dangers to public interests were as manifest as those to private. Rates became unreasonable, inequitable, and instable, because the roads were forced to compensate for their losses in competitive areas by charging discriminatory rates in non-competitive territories. These rate wars and their evil consequences were the indirect if not the direct cause of public regulation. The experience of this and other countries shows that competition and not cooperation has given rise to the most important phases of the railroad problem, and that public interest is served better by proper control over railroad cooperation. This idea of regulation has expanded until today practically every branch and element of railroad service is subject to public control.

After years of Federal regulation of interstate commerce, the fear of combined action by our railroads has, to a large extent, yielded to a constructive policy of encouraging consolidations along lines which meet with the approval of the Interstate Commerce Commission. Railroads, after passing through many stormy periods, have finally come to a point where they are encouraged to solve their problems of rendering better service at lower costs by combining into a limited number of large systems. This was the principle laid down in the Transportation Act of 1920, when Congress authorized railroads to consolidate according to plans recommended or approved by the Interstate Commerce Commission. That Commission is now engaged in attempting to devise a grouping of roads that will produce unity, greater efficiency, and better service. In this no new economic principle is being expressed; there is only the stamp of public approval placed upon a movement that has been marching on steadily since the advent of the steam locomotive. There is now a more wide-spread consciousness of the advantage of a unified transportation service. Early consolidations were of connecting lines; present consolidations are of not only connecting roads, but of roads serving different and the same territories.

The Interstate Commerce Commission is confronted today by the stupendous problem of bringing about a consolidation of railroads according to plans which aim to establish more unified, adequate, efficient, and economical

service. The voluntary combinations among railroads have been based primarily upon profit-making considerations. The public welfare has been incidental and has been injected only through the action of the Federal and State Governments and other interested parties.

The Interstate Commerce Commission, in formulating a consolidation program, is between two opposing forces. On one side, there is the desire of each railroad to retain its own properties unless encouraged to consolidate by an opportunity for gain. Coupled with this is the desire of the large systems to acquire only profitable lines or those with profit-making potentialities. If allowed to effect combinations dictated by financial considerations alone, weaker roads, serving sections poor in resources or undeveloped. would be isolated. The advantages of large-scale operation would accrue to rich areas more fully developed and perhaps enjoying competitive conditions; while the poorer territories would tend to remain poor. They at least would not benefit by better and cheaper railroad service as accomplished through large consolidations.

On the other side, there is the fear that certain communities will be deprived of adequate service or suffer from some form of discrimination or neglect. There remains, also, a strong vestige of the distrust of monopoly power. Much of the fear of inadequate facilities and discrimination would be largely dissipated if two decades ago the Interstate Commerce Commission had started to outline and enforce a program of consolidation. A lack of legal power, doubtless, has been a deterrent, but more significant has been government inertness resulting from a failure on the part of the public to envisage the problem and to prepare for the rising tide of railroad combinations privately conceived and executed.

This tendency toward the consolidation of railroads has its parallel in a related branch of public utility service,—the generation, transmission, and distribution of electric current. The combination of electric companies is destined to exert a powerful influence upon social life, and forms an essential part of one of the most significant movements in any private or public enterprise today,—namely, the integration of electric generating, transmission, and distribution facilities, or what is more commonly known as "Giant Power" development. From a public standpoint, the advantages of integration of electric companies will be making a cheaper and more convenient form of power more generally available for homes, industries, railroads, and farms. This will produce salutary effects in urban and rural life and will result in revolutionary changes in America's most important and basic occupation,—agriculture.

The Public Service Commission of Pennsylvania is being confronted today by the same conditions with respect to electric utilities as confront the Interstate Commerce Commission with respect to railroads. Power companies are spreading out and merging other units. These combinations, privately initiated, are based, not upon the best interests of the State as a whole, but are organized according to the interests of the dominant company back of the movement. The Public Service Commission is endeavoring to view combinations of electric utilities from a state and interstate point of view, and is endeavoring to preserve public interests and at the same time encourage

legitimate business expansion. The Commission fully appreciates the advantages and desirability of combination in this field, and its plans are predicated upon this idea; but it realizes also that the consolidations must be subjected to careful investigation with a view to determining the economic and general social consequences.

Combinations of electric companies are not unlike those of railroads. The first groupings are of connecting utilities or of those serving adjacent communities which frequently constitute a single economic section of the State. There follow consolidations of large units, with a view to tying together generating stations and transmission lines and thus effecting a more unified service. The extent to which this form of combination might be developed is difficult to forecast, but it is evident that the end has not been reached.

That combinations in the production and distribution of electrical energy are being effected at an unprecedented rate, and are assuming large proportions, is evidenced monthly by applications which come before The Public Service Commission for the incorporation, merger, consolidation, and purchase of a controlling interest in capital stock of electric companies.

Before presenting statistical data bearing upon the extent or scope of combination, a few brief definitions of terms used will serve to clarify the various methods employed and the reasons why certain legal processes are resorted to.

SIMPLE INCORPORATION

An important forerunner to extending the territory which a utility serves is the incorporation of new companies with franchise privileges to construct and operate power facilities in certain limited areas. These companies are usually brought into existence through simple incorporation. By this term is meant the organization of distinctly new companies in which mergers or consolidations are not directly involved. Without attempting to engage in an elaborate discussion of legal distinctions, it may be pointed out that there are three types of corporations included in this class,—steam electric companies, hydro-electric companies, and electric transmission companies.

The part played by simple incorporation in plans for consolidating utilities will be seen from an examination of the statistical information given below.

STEAM ELECTRIC COMPANIES

The steam electric company is the most common form of simple incorporation, and is organized with the power to manufacture, distribute, and supply light, heat and power. For this reason, these corporations are usually known as light, heat and power companies.

The Steam Electric Act of 1899, does not designate the manner in which electric current is generated, hence it has been recently ruled by the Attorney-General's Department of the Commonwealth of Pennsylvania that such a corporation may generate its current by either steam or water power. The Steam Electric Act limits the charter territory of a corporation to a borough, city, town or district and the territory adjacent thereto; and it has ruled (Brown *vs.* Electric Light Company, 208 Pa. 453) that the term "district," as used in the Act of 1899, in similarity to a like provision for the incorpora-

tion of water companies, is to be taken as meaning a part of a borough, city, town or township, and that, therefore, a steam electric company cannot be formed for two or more municipalities or for parts of two or more municipalities. The result of these legal restrictions is that recent corporations of this class are usually organized with charter privileges limited to a single township, and are frequently called "township companies."

HYDRO-ELECTRIC COMPANIES

Hydro-electric companies are in legal contemplation corporations which have been chartered as water power companies, and which are given the additional right to generate and supply electric current from water power.

It appears that water power companies may be organized as local companies enabled to function in a restricted territory, or as companies with broader territorial privileges.

It has been ruled by the Attorney General that steam electric companies may develop current from water power, but it does not necessarily follow that water power companies may generate current from steam. The law would seem to be the other way, for it is a principle of law that corporations have only such powers as are expressly conferred or necessarily implied by such expressed conference; and since the hydro-electric company is given the right, by statutory law, to generate electricity only by means of water power, this expression of the one manner of generating the current would seem to carry with it a negation of all other matter. This restriction upon the rights of hydro-electric companies has caused them to incorporate steam electric companies where it is desired to augment the supply of current by the construction of a steam generating plant. A recent instance of this has been the incorporation of the Holtwood Power Company by the Pennsylvania Water and Power Company, a hydro corporation. The former company is to construct a steam electric generating station at Holtwood, on the eastern shore of the Susquehanna River, and is to sell and deliver all its current to the Pennsylvania Company. The latter company is to own all the capital stock of the new corporation.

This restriction of legal power has caused the legal and other expenses incident to giving birth to a new corporation, and is an unfortunate and useless obstacle to business progress.

ELECTRIC TRANSMISSION COMPANIES

Electric transmission companies are organized for the sole purpose of transmitting electricity or for tying in of generating stations owned by different utilities. The function of corporations, with the sole authority of transmitting electric energy, is not specifically provided for in the statutory laws of the Commonwealth. They are formed under the Act of 1909, P. L. 515, which authorizes the formation of corporations for any other purpose not otherwise specifically provided for. There are few of these transmission companies in existence, the probable explanation being that there is no statute conferring on them the right of eminent domain, so that the expense necessary in purchasing the right-of-way for the transmission line would be in most cases prohibitory.

Merger, Long Form (Consolidation)

By the Act of May 3, 1909, P. L. 408, it is provided that corporations of a similar character may merge their corporate entities, and it has been judicially determined (Penna. Utilities Company *vs.* Public Service Commission, 69 Pa. Supre. Ct. 612) that the effect of such merger is to bring into being a new corporation, separate and distinct from the constituent companies. This form of corporate union is generally known as a "consolidation."

By this process, if companies A, B, C, and D are to be combined, a new corporation, X, is incorporated to take over the rights, franchises, and properties of the four original corporations. The old companies are automatically dissolved and cease to exist as corporate entities when the new corporation comes into being.

Sales—Known as a Short Merger

Under an Act of April 17, 1876, P. L. 30, one corporation is authorized to sell its property, franchises, and privileges to another corporation. In case of a short merger, no new company is organized, but one of the old companies buys out or absorbs the others. The companies bought out then pass out of existence. Thus, X, a large operating company might purchase the rights, franchises, and properties of A, B, C, and D companies, and then dissolve the absorbed entities.

The fundamental distinction between a long and a short merger is that in the former a separate and distinct corporate entity comes into existence, whereas, in case of the latter, the corporate entity of the purchasing, or vendee, company remain *in esse*, while that of the selling company disappears.

Indirect Forms of Corporate Unification

While the above are the direct methods of effecting a legal unification of electric companies, there are certain indirect processes which are substantially as effective in bringing about unity of corporate relationship, in that they give one corporation the power to control the property or product of another, and, in case of stock control, the power to determine financial, as well as operating policies. These methods are stock control, lease of facilities, and exclusive contracts for purchase of current.

Stock Control

As the ownership of stock, particularly the common, carries with it the right to control the enterprise, the control by one electric company of the stock of another, gives to the vendee company the power to determine the financial and operating policies of its subsidiary or affiliated companies. Under the provisions of The Public Service Company Law of Pennsylvania, such control is subject to the approval of The Public Service Commission.

Lease of Facilities

By a lease agreement one company may obtain the possession and use of all or a part of the properties of another. The corporate entities are retained and kept distinct. Such leases among utilities are subject to the approval of The Public Service Commission.

SALE OF CURRENT

When one company agrees to sell the entire output of its product to another, there is established a corporate relationship which is practically as effective as the other forms. The contracts binding the corporations are so comprehensive that the companies are in effect united into one.

ANALYSIS OF INCORPORATIONS AND COMBINATIONS OF ELECTRIC COMPANIES IN PENNSYLVANIA

The information upon which the study of incorporations and combinations is based was obtained from the Application Docket of The Public Service Commission of Pennsylvania. A corporation does not come into being until letters-patent have been issued by the Governor of the Commonwealth; but for the purpose of this analysis the existence of a corporation was dated from the approval of The Public Service Commission.

SIMPLE INCORPORATIONS

During the year 1923, 365 new companies were organized by simple incorporation; and, during the first nine months of 1924, January to September, inclusive, 141 new companies were formed in this manner. During the first nine months of 1923, 300 incorporations were approved. The decline from 300 in 1923 to 141 in 1924 might be due to the fact that the preponderant majority of simple incorporations are of township companies organized for the purpose of acquiring franchise rights in individual townships. Chartered as steam electric companies, their territorial rights are restricted to a single township. A saturation point is being approached, and the time is not far distant when there will be, or will have been, a township company, perhaps existing on paper only, for each township. This, of course, will curtail the rate at which such companies are brought into existence.

Judging by the rate at which township companies are being organized, considerable haste is being manifested. What is the explanation? At the 1923 Session of the State Legislature, an Act was passed constituting the Giant Power Survey Board, to make an intensive study of the electric power situation in Pennsylvania, with view to outlining a policy for the development of the electric industry. Possibly anticipating some form of territorial distribution, the utilities have lost no time in obtaining franchise privileges indirectly through the media of paper companies.

Of the 363 incorporations effected in 1923, 114 were absorbed, during the year, under the Short Merger Act of 1876, and 41 were merged or consolidated under the Long Merger Act of 1909. During the first nine months of 1924, there were mergers of 119 companies organized in 1923. Eighty of these companies were absorbed under the Short Merger Act, and 39 were merged under the Long Merger Act. Adding the 119 companies merged and absorbed during the nine months of 1924 to the 155 merged and absorbed in 1923, the total of the mergers of 1923 companies is found to be 274, or 75.5% of the 363 simple incorporations of that year. Doubtless, some of the remaining 89 companies will be merged during the last three months of 1924, and subsequently.

Of the 141 companies brought into existence during the nine months of

1924, 62 were absorbed during the same period under the Short Merger Act, and 5 were merged or consolidated under the Long Merger Act. During the first nine months of 1923, 71% of the mergers were under the former law, whereas, during the same months in 1924, 91% were under this Act. This change in the percentage absorbed by short mergers might have no particular importance, other than that the existing utilities are employing direct mergers rather than first forming new companies to consolidate smaller operating or paper companies. During 1923, for instance, twelve new corporations were formed as consolidations of 90 other companies. During the same year, four of these 12 consolidated companies were absorbed, through short mergers, by existing utilities.

The 67 mergers of 1924 companies do not completely indicate the tendency of electric companies to combine, because the majority of mergers of 1924 companies were of those organized during the earlier months of the year. In other words, for the companies brought into existence during the last months of the period, there was insufficient time for applications for mergers and consolidations to be filed and passed upon by the Commission. This is substantiated by the following tables, which show the simple incorporations effected during 1923 and the first nine months of 1924, the number of 1923 companies merged during 1923, and the 1924 companies merged during 1924. It is evidenced, further, by the 119 mergers of 1923 companies during the first nine months of 1924.

COMPANIES INCORPORATED IN 1923 AND MERGED DURING THE YEAR

Incorporated Period	Number	*Merged During Year*	*Per Cent. of Merged to Incorporated*
First 4 Months	128	73	57%
First 5 Months	141	76	54
First 6 Months	194	113	58
First 7 Months	204	119	53
First 8 Months	211	120	56
First 9 Months	300	143	47
First 10 Months	329	144	47
First 11 Months	354	155	44
First 12 Months	363[1]	155	43

[1]To show how active the consolidating tendency has become, the following are the number of *applications* for incorporation of electric companies filed with P. S. C. in years just prior to 1923.

1919	147
1920	127
1921	103
1922	178

The figures used in this paper are for approval of applications.—*Editor*. ....

COMPANIES INCORPORATED DURING FIRST NINE MONTHS OF 1924 AND MERGED DURING THE PERIOD

Incorporated		*Merged During 9 Months*	*Per Cent. of Merged to Incorporated*
Period	*Number*		
First 4 Months	50	37	74%
First 5 Months	84	60	71
First 6 Months	84	60	71
First 7 Months	93	66	71
First 8 Months	138	67	48
First 9 Months	141	67	47

These tables indicate that distinctly new companies are brought into existence almost solely with the object of their being combined into new companies or for being absorbed by existing electric corporations. The analysis of 1923 companies revealed, further, that only five could be identified as operating companies, the remaining 358 having been brought into existence for the purpose of acquiring territorial rights to serve electric energy. They are for the most part paper companies existing in name only and representing an effort to preempt territory for an existing corporation or for one contemplated as a merger of smaller units.

What is the significance of this process and movement? The method is resorted to because electric companies authorized to generate current by steam power may not be chartered to serve more than one municipality. The larger municipal units are already supplied with electric service, and the municipalities without service are townships. In order to reserve for themselves these areas and to defend what they consider their proper electrical districts, the larger utilities are forming these township companies and then absorbing them. If this acquisition of territory is allowed to take place according to the will of the individual utilities, and without being guided by any preconceived public plan and policy, the Commonwealth will become a confused patchwork of franchise territories with no evidence of a design intended to guarantee against duplication of transmission lines and the wasteful construction of generating facilities. As has been pointed out, it is such duplication and haphazard division of territory which must be prohibited as contrary to sound public policy and the economics of public utility operation and regulation. It is to be anticipated that this condition will produce, at no remote time, bartering among the utilities themselves for new alignments of territory. Bargains will be driven according to bargaining power, and there will remain the danger that certain districts will suffer from the absence of service. This can be prevented by action of The Public Service Commission only when the utility is chartered to enter the territory. A constructive legislative enactment, designed to provide service in communities where service should be rendered, regardless of original charter provisions, would be to confer upon The Public Service Commission the power to order electric companies to enter and serve territories for which the utilities are not chartered. This would assure extension of service to the more isolated

communities in case the Commission became convinced that such extension is socially expedient and fair.

MERGERS—LONG FORM (CONSOLIDATIONS)

During the year 1923, 90 electric companies were combined to form 12 new units, 11 of which became operating utilities. These 11 companies were formed as consolidations of 57 paper companies and 15 operating. Of the 11 new operating companies, only 9 remain, two having been absorbed during the same year by other companies under the Short Merger Act of 1876. One company was reincorporated with a slight change in corporate name.

An examination of the size of the merged operating utilities shows that four had revenues in excess of one million dollars each, the combined income of these four companies being $5,914,221 in 1922. Two of the merged companies had revenues between $100,000 and $500,000; three between $50,000 and $100,000; three between $5,000 and $35,000; and three with less than $5,000.

During the first nine months of 1924, 48 companies were merged to form five new units, two of which became operating companies; one became a transmission line company; and the remaining two existed as paper companies. The two operating companies represented a consolidation of three paper companies and two operating companies. One of the absorbed operating utilities had a revenue in 1923 of $81,626.75, and the other a revenue of $9,917.67.

As further evidence of the methods used in acquiring territory, one of the companies formed in 1924 by long merger was a consolidation of 32 township companies. This new corporation was later absorbed during the same period by one of the largest operating electric utilities in the State.

SHORT MERGERS

In 1923, 223 companies were absorbed by 31 existing corporations, all of which, with one exception, were operating utilities. Of the 223 companies, 204 were of the township paper variety and probably organized by the vendee corporations in order to obtain franchise rights. The analysis of companies brought into existence by simple incorporation shows that 114 of the 204 merged companies, were organized during 1923.

Four of the absorbed units were transmission line companies, all being likewise paper organizations. Four of the merged corporations were formerly leased by the vendee. The remaining eleven merged companies had been operating utilities. An examination of the merged operating utilities reveals that one had a revenue in 1922 of $578,607; one a revenue of $155,000; one $90,000; two had revenues between $25,000 and $50,000; and five between $5,000 and $25,000.

In 1924, four of the above vendee companies were absorbed, in turn, by other large operating utilities. Three of these absorbed utilities, with revenues in 1923 aggregating $875,744.27 were acquired by a single corporation which itself had a revenue in 1923 of $4,279,379.64. During the first nine months of 1924, this latter company acquired two smaller utilities having a combined revenue of $9,999. This merger is a good illustration of how consolidations

are accelerated by the merger of larger utilities and gives an excellent idea of the magnitude of the problem and the complexity of the economic and financial interests and considerations. Public control of these operations is obviously a tremendous problem involving a ramification of questions and considerations.

To make the problem still more involved the vendee company, referred to above, first acquired a controlling right, title and interest in the capital stock of the three large operating utilities. Having obtained stock control, the underlying companies were then legally terminated and their properties made an integral part of the vendee company's system. The vendee company acquired a controlling interest, also, in the capital stock of another electric company having an approximate revenue of $1,200,000, but this utility has not yet been absorbed.

During the first 9 months of 1924, 176 companies were absorbed by 23 existing companies, all of which, with one exception, were operating utilities. Of the 176 merged companies, 154 were paper companies. A further analysis shows that 62 of the 176 companies were organized during 1924, and 80 were 1923 incorporations. The remaining 34, of the 176 companies, were formed prior to 1923 and it is safe to say that most of them came into existence during 1922.

Two of the absorbed units were transmission line paper companies. Three of the merged corporations were formerly leased by the vendee. The remaining 17 units had been operating utilities, eight of which had revenues of less than $25,000; one a revenue of $28,598; three revenues between $50,000 and $100,000; and the remaining five had revenue between $100,000 and $500,000. As pointed out in connection with the short mergers of 1924, three of the absorbed utilities, with a combined revenue of $875,744.27, were absorbed by a large corporation which previously had a volume of business amounting to $4,279,379.64. In brief, during the 9 months, three companies acquired seven other companies having a combined revenue of $1,241,634.

CONTROLLING INTEREST IN CAPITAL STOCK[1]

The direct and most secure forms of combination are by long and short mergers. These give the vendee company the ownership and possession of the properties of the merged units and the complete and sole rights formerly held by the defunct utility. But substantially as effective, however, in establishing control, or the right to determine policy, is the ownership of all or a large percentage of the stock of another company. As the ownership of stock carries with it the right to chart the operating and financial course of the enterprise, control is thereby established.

By this method, 5 corporations during the year 1923, obtained control over 18 other companies, 15 of which were operating utilities with revenues ranging from $24,724 to $1,200,000 and having an aggregate revenue of

[1]The Pennsylvania Public Service Commission has jurisdiction over holding companies only to the extent that they are operating companies in the State. If one operating utility acquires a controlling stock interest in another, or purchases its property, approval of the Commission must be obtained. Commission should have same jurisdiction over acquisitions by holding companies. Only in this manner can it exercise complete control over combinations.—*J. L. S.*

$3,232,178. Two of the vendee companies were organized during 1923 and apparently for the purpose of merging and absorbing other companies and acquiring controlling interest in the stock of utilities. One of these two companies was absorbed in 1924 by another large operating utility. It has been explained, under short mergers, that one vendee company acquired the controlling interest in the capital stock of three operating utilities having an aggregate revenue of $694,411, and subsequently, during the same year it absorbed these companies by short merger.

During the year 1924, three corporations acquired a controlling right, title and interest in the capital stock of four operating utilities which in 1923 had a combined revenue of $75,052.63. A comparison with the year 1923 shows that the combinations by this method during 1924 were less momentous than during 1923.

CONCLUSIONS ON INCORPORATIONS AND MERGERS

The studies of incorporations and combinations in the field of generating and distributing electrical energy give convincing evidence that the preponderant majority of simple incorporations were of paper companies existing in name only for the purpose of acquiring territorial rights. The fact that of the 363 corporations organized during 1923, by simple incorporation, 274, or 75.5%, were merged and absorbed by other companies by the end of September, 1924, a period of 21 months, must lead to the conclusion that these small township companies are organized by large operating utilities so that the latter can take over the franchise rights to serve certain areas of the Commonwealth. The time is rapidly approaching when there will have been a township company incorporated for each township in which economic conditions and population encourage or make possible the promotion of such an organization. Most of these units will be absorbed by operating utilities seeking to extend the domain of their electric service.

The analysis of short mergers indicates that there is a pronounced tendency among electric utilities to unite into a comparatively small number of large companies. The usual procedure has been for the operating utility to organize small township and transmission units and later absorb these directly by short merger or indirectly by long merger, the company organized by a long merger frequently being absorbed later by the large operating corporation.

It would be interesting to compare the number of operating electric utilities at the beginning of 1923 with the number at the close of the year and to make the comparison on the basis of revenue. The nearest approach to this information is found in the short mergers for 1923 where it is shown that eleven operating utilities with a combined revenue of $2,209.828. were absorbed by six corporations.

The rate at which combinations are being effected, and the apparent eagerness at times of large companies to absorb the smaller and to preempt territory for their own service, have made it imperative for The Public Service Commission to exercise all its legal powers in safeguarding the public interests. There is an imminent danger that a company in its eagerness and desire to expand will be led, or forced, to pay unwarranted prices for the

absorbed units, because of the threat of neighboring utilities to penetrate what the first company regards as its logical territory. The smaller company, if it senses the strategic position which it occupies in the development of a large system, can hold off and compel the expanding utilities to bid against one another. There is present a form of aggrandizement which may become threatening to the legitimate development and economically sound policy of an electric company. It is readily seen that the result may be the payment of a price for the absorbed company which is wholly out of proportion to its intrinsic worth.

Other serious evils to be committed are the overlapping of territory, needless multiplying of generating stations involving millions of capital invested, and a wasteful paralleling of high voltage transmission lines. The inevitable result of such circumstances and the payment of unreasonable considerations would be to impose upon any utility, imperialistically inclined, high fixed capital charges which the public would ultimately be called upon to carry through rates to yield a fair return on property.

VIII. GIANT POWER ACTS AS PASSED BY 1923 LEGISLATURE

No. 186

AN ACT

Authorizing the Department of Forestry to grant, on terms, conditions, and stipulations, rights to occupy and use any portions of the State forests for dams, reservoirs, canals, pipe lines, and other water conduits, for certain water supply purposes; and providing remedies for violations of this act, or regulations or orders hereunder, or of such terms, conditions, or stipulations; and providing for revocation of the grant in certain cases.

Section 1. Be it enacted, &c., That the Department of Forestry is hereby authorized, in its discretion, to grant the right to occupy and use any portions of the State forests for use as sites for dams, other water obstructions, reservoirs, canals, pipe lines, and other water conduits, for supplying water otherwise than for steam condensation. Every such grant shall be on such terms, conditions, and stipulations as the department shall deem necessary for the protection of the present and future interests of the Commonwealth and its people, and suitable for affording a reasonable opportunity for a fair return on the actual investment, prudently made, on the faith of such grant.

Section 2. That the Attorney General may, on the request of the Water Supply Commission, institute proceedings in any court, now or hereafter clothed with jurisdiction in cases in which the Commonwealth is a party, for the purpose of revoking, for violation of its terms, any permit issued hereunder; or for the purpose of remedying or correcting, by injunction, mandamus, or other process, any action of commission or omission in violation of the provisions of this act or any lawful regulation or order promulgated hereunder. The said courts shall have jurisdiction over all the above-mentioned proceedings, and shall have power to issue and execute all necessary process,

and to make and enforce all rights, orders, and decrees to compel compliance with the law, orders, and regulations of the Commissioner of Forestry in respect of any so permitted dam, water obstruction, or appurtenant works, and to compel the performance of any condition imposed under the provisions of this act. In the event a decree revoking a permit is entered, the court is empowered to sell the whole or any part of the dam or other water obstruction, together with any or all appurtenant works, lands, and water rights; to wind up the business of such permittee conducted in connection with such dam or water obstruction; to distribute the proceeds to the parties entitled to the same; and to make and enforce such further orders and decrees as equity and justice may require. At such sale or sales the vendee shall take the rights and privileges belonging to the permittee, and shall perform the duties of such grantee and assume all outstanding obligations and liabilities of the grantee which the court may deem equitable in the premises.

Approved—The 21st day of May, A. D. 1923.

Gifford Pinchot.

The foregoing is a true and correct copy of the Act of the General Assembly No. 186.

Clyde L. King,
Secretary of the Commonwealth.

No. 239

AN ACT

Authorizing the creation of a commission to negotiate with the duly constituted agents of the States of New York and New Jersey for the regularization of the flow of the Delaware River, the conservation, apportionment, and utilization of the water resources thereof; providing the method of ratification of such compact by this Commonwealth; and prescribing the conditions of its being in full force and effect.

Section 1. Be it enacted, &c., That the Governor of the Commonwealth is hereby authorized to designate three officers of the Commonwealth as commissioners with power to negotiate with the duly authorized agents of the States of New York and New Jersey a compact, in accordance with the Constitution of the United States, for the regularization of the flow of the Delaware River, the conservation of the water resources of the Delaware Basin, the apportionment thereof among the said States for domestic and municipal supply, and the utilization thereof for power and other beneficial uses.

Section 2. The compact negotiated by the said commissioners shall be submitted by the Governor to the General Assembly, and, the Congress of the United States having consented thereto, shall be in full force and effect upon its ratification by duly enacted law of this Commonwealth, and by

the States of New York and New Jersey as their laws may respectively prescribe.

APPROVED—The 24th day of May, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 239.

CLYDE L. KING,
Secretary of the Commonwealth.

No. 240.

AN ACT

Providing for a giant power survey; creating a Giant Power Survey Board; defining the powers and duties thereof; requiring officers, departments, commissions, and other agencies of the Commonwealth to give information thereto; and making an appropriation.

Section 1. Be it enacted, &c., That the Governor, the Attorney General, the Commissioner of Forestry, the Secretary of the Water Supply Commission, the Chairman of the Public Service Commission, the Secretary of Agriculture, the Commissioner of Labor and Industry, the State Geologist, a Deputy Attorney General, to be designated, from time to time, by the Governor, and a competent engineer, to be designated, from time to time, by the Governor, are hereby created a Giant Power Survey Board, hereinafter called the board. The Governor shall be chairman of the board.

Section 2. It shall be the duty of the board to undertake an outline survey of the water and fuel resources available for Pennsylvania, and for the most practicable means of their full utilization for power development, and other related uses; also to recommend, in outline, such policy with respect to the generation and distribution of electric energy as will, in the opinion of the board, best secure for the industries, railroads, farms, and homes of this Commonwealth an abundant and cheap supply of electric current for industrial, transportation, agricultural, and domestic use. The board shall investigate the practicability of, and make recommendations concerning, the establishment of giant power plants for the generation of electricity, by fuel power, near coal mines, the transmission and distribution of the electric energy so and otherwise generated throughout the Commonwealth; the saving and utilization of the by-products of coal, to be consumed in such giant power and other plants; the electrification of railroads; the generation of electrical energy by water power; and the coordination of water power and fuel power development with the regulation of rivers, by storage and otherwise, for water supply, transportation, public health, and recreation, and other beneficial uses.

Section 3. In making its investigations and reports, the board shall make use of all available information heretofore collected by the Commonwealth, and all other published, or otherwise readily obtainable, information within the scope of its inquiry. Every officer, department, commission, and other

agency of the Commonwealth, possessing such information, shall furnish the same to the board and as the Governor may, from time to time, direct.

Section 4. It shall be the duty of the board, in its investigations and report, to study and consider the best practicable utilization of streams for navigation, water supply, purity of waters, river regulation, and flood prevention, in relation to power; and both as to waters and as to the generation and distribution of electric energy, to keep in view the mutual interests of this Commonwealth and other States; and to outline plans for the interchange of electrical energy with all other States within the practicable transmission distance.

Section 5. The engineer designated as a member of said board shall be paid such compensation as shall be fixed by the Governor of the Commonwealth. The other members of the board shall serve without additional compensation.

Section 6. The report of the board shall be submitted to the General Assembly at the opening of the regular session in January, one thousand nine hundred and twenty-five.

Section 7. The sum of thirty-five thousand dollars ($35,000.00) is hereby specifically appropriated for the payment of the compensation of the engineer, from time to time, designated as a member of the board, the compensation of necessary technical, clerical, and other assistance, the purchase of necessary supplies, the rent of necessary quarters in Harrisburg and elsewhere, necessary travel of the members of the board and its employes, their necessary subsistence when absent from their regular places of employment, necessary printing, and all other necessary expenses incurred in the performance of the duties imposed under this act.

APPROVED—The 24th day of May, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 240.

CLYDE L. KING,
Secretary of the Commonwealth.

No. 293

AN ACT

Authorizing the condemnation and appropriation of lands, waters, and other property by public service companies holding limited power permits and limited water supply permits granted by the Water Supply Commission of Pennsylvania, and providing a method for the assessment of damages arising from such appropriation.

Section 1. Be it enacted, &c., That where used in this act singular words shall be construed as including the plural, masculine words shall be construed as including the feminine and neuter, and the following terms shall have the following meanings respectively designated for each:

The term"commission" means the Water Supply Commission of Pennsylvania.

The term "dam" means a dam, wall, wing wall, wharf, embankment, abutment, projection, or similar analogous structure, or any other obstruction whatever in, along, across, or projection into any stream or body of water wholly or partly within, or forming part of the boundary of, this Commonwealth, except tidal waters of the Delaware River and of its navigable tributaries.

The term "dam to develop water power" means a dam for the purpose of developing water power only, or a dam for said purpose and any other purpose.

The term "dam to supply water for steam power" means a dam for the main purpose of storing, cooling, diverting, and using, or any of them, water for steam raising or steam condensation, or both, in the generation of electric energy for use in public service, which is not a dam to develop water power as hereinbefore defined.

The term "water supply dam" means a dam for the purpose of supplying water, which is not a dam to develop water power nor a dam to supply water for steam power as hereinbefore defined.

The term "power dam" includes dams to develop water power and dams to supply water for steam power.

The term "change in stream to develop water power" means any change in or diminution of the course, current, or cross-section of any stream or body of water for the sole purpose of developing water power, or for said purpose and any other purpose, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream to supply water for steam power" means any such change or diminution for the main purpose of storing, cooling, diverting, and using, or any of them, water for steam raising or steam condensation, or both, in the generation of electric energy for use in public service, which is not a change in stream to develop water power as hereinbefore defined, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream for water supply" means any such change or diminution for the purpose of supplying water, which is not a change in stream to develop water power, nor a change in stream to supply water for steam power, as hereinbefore defined, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream to develop power" includes changes in stream to develop water power and changes in stream to supply water for steam power.

The term "power project" means a complete unit of improvement or development for the procuring or supply, or both, of water power, or the procuring or supply, or both, of light, heat, and power, or any of them, by electricity, consisting of a power dam or change in stream to develop power, or both, for which a limited power permit at any time is being sought or shall have been granted, a power house, all water conduits, dams and appurtenant works which are a part of said unit, and all storage, diverting, or forebay reservoirs directly connected therewith, the primary line or lines transmitting power from the power house to the point of junction with the distribution

system or with an interconnected primary transmission system, all miscellaneous structures used and useful in connection with such unit, or any part thereof, and all water rights, rights of way, ditches, dams, reservoirs, lands or interests in lands, the use and occupancy of which are necessary or appropriate in the construction, maintenance, and operation of such unit.

The term "water supply project" means a complete unit of improvement or development for the procuring or supply, or both, of water, which is not a power project as hereinbefore defined, consisting of a water supply dam or change in stream for water supply, or both, for which a limited water supply permit at any time is being sought or shall have been granted, a reservoir, the dam and other works appurtenant thereto, and all primary water conduits leading immediately therefrom to the point of junction with the distribution system or with an interconnected primary water conduit, and all water rights, rights of way, ditches, dams, reservoirs, and lands or interests in lands, the use and occupancy of which is necessary or appropriate in the construction, maintenance, and operation of such unit.

The term "permittee" means the holder of a limited power permit or of a limited water supply permit, and his heirs, successors, and assigns.

The term "limited power permit" means a permit for a power dam or for a change in stream to develop power, or both, hereafter granted by the commission.

The term "limited water supply permit" means a permit for a water supply dam or for a change in stream for water supply hereafter granted by the commission.

Section 2. Any public service company holding a limited power permit or limited water supply permit, granted on behalf of a power project or a water supply project for use in public service, shall have the right and power to appropriate and condemn, overflow, submerge, occupy, and use any street, road, lane, alley, turnpike, highway, bridge, electric railroad, or steam railroad, whether publicly or privately owned, which the commission shall find to be necessary for the construction, maintenance, or operation of the power project or water supply project in behalf of which such permit was granted: Provided, That such permittee shall cause the same, and all structures of other public service companies located thereon, to be reconstructed, at his own proper expense, on such location and in such manner and to such extent as the commission may require, or shall reimburse such other public service company for the reasonable cost of such relocation and reconstruction, and such permittee may condemn and appropriate property which the commission shall find to be necessary for such relocation and reconstruction.

Section 3. Any public service company holding a limited power permit or a limited water supply permit, granted on behalf of a power project or a water supply project for use in public service, shall have the right and power to condemn and appropriate any lands, waters, and other property and rights, as to which the said commission, after due notice and public hearing, shall have found that the appropriation of the same is required by the present and future interests of the Commonwealth for the construction, maintenance, or operation of the project in behalf of which such permit is granted, and is not

incompatible with the public interests of the region in the vicinity of such project.

Section 4. All damages arising from the exercise of the right and power of condemnation conferred by section two and three of this act shall be ascertained, recovered, and paid as provided by the forty-first section of the act, approved April twenty-ninth, one thousand eight hundred and seventy-four (Pamphlet Laws, seventy-three), and the amendments and supplements thereto.

Section 5. None of the rights and powers conferred by this act shall be so used as to permit the utilization of any system of distribution, acquired, constructed, erected, used, or operated through the power of condemnation or appropriation conferred by this act, to supply, or commence to supply, within the limits of any city, borough, township, or district, in which, at the time of said commencement or proposed commencement, a company incorporated for the supply of light, heat, and power, or any of them, to the public by electricity is lawfully supplying light, heat, and power by electricity, without first securing a certificate of public convenience from the Public Service Commission of the Commonwealth of Pennsylvania authorizing such use within such limits. Nor shall this act be construed as impairing or limiting any right or power of eminent domain otherwise conferred by law.

APPROVED—The 14th day of June, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 293.

CLYDE L. KING,
Secretary of the Commonwealth.

No. 294

AN ACT

Relating to limited power permits and limited water supply permits from the Water Supply Commission of Pennsylvania and the conditions thereof, to the flooding and use by holders of limited power permits of islands owned by the Commonwealth, to the unlawful use for water or steam power development of dams and changes in streams hereafter constructed or made otherwise than under limited power permits, and to proceedings for the enforcement of this act.

Section 1. Be it enacted, &c., That where used in this act singular words shall be construed as including the plural, masculine words shall be construed as including the feminine and neuter, and the folowing words shall have the following meanings respectively designated for each:

The term "commission" means the Water Supply Commission of Pennsylvania.

The term "dam" means an obstruction, dam, wall, wing wall, wharf, embankment, abutment, projection, or similar analogous structure, or any other obstruction whatever in, along, across, or projecting into any stream or body of water wholly or partly within, or forming part of the boundary of this Commonwealth, except the tidal waters of the Delaware River and of its navigable tributaries.

The term "dam to develop water power" means a dam for the purpose of developing water power only, or a dam for said purpose and for any other purpose.

The term "dam to supply water for steam power" means a dam for the main purpose of storing, cooling, diverting, and using, or any of them, water for steam raising or steam condensation, or both, in the generation of electric energy for use in public service, which is not a dam to develop water power as hereinbefore defined.

The term "water supply dam" means a dam for the purpose of supplying water, which is not a dam to develop water power nor a dam to supply water for steam power as hereinbefore defined.

The term "power dam" includes dams to develop water power and dams to supply water for steam power.

The term "change in stream to develop water power" means any change in or diminution of the course, current, or cross-section of any stream or body of water for the sole purpose of developing water power, or for said purpose and any other purpose, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream to supply water for steam power" means any such change or diminution for the main purpose of storing, cooling, diverting, and using, or any of them, water for steam raising or steam condensation, or both, in the generation of electric energy for use in public service, which is not a change in stream to develop water power as hereinbefore defined, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream for water supply" means any such change or diminution for the purpose of supplying water, which is not a change in stream to develop water power, nor a change in stream to supply water for steam power, as hereinbefore defined, whether the dam or other means effecting the change be within or without the Commonwealth of Pennsylvania.

The term "change in stream to develop power" includes changes in stream to develop waterpower and changes in stream to supply water for steam power.

The term "limited power permit" means a permit for a power dam or for a change in stream to develop power, or both, granted under this act.

The term "limited water supply permit" means a permit for a water supply dam or for a change in stream for water supply, or both, granted under this act.

The term "power project" means a complete unit of improvement or development for the supply of water power, or for the procuring or supply, or both, of light, heat, and power, or any of them, by electricity, consisting of a power dam or change in stream to develop power, or both, for which a limited power permit at any time is being sought or has been granted, a power house, water conduits, all dams and appurtenant works which are a part of said unit, and all storage, diverting, or forebay reservoirs directly connected therewith, the primary line or lines transmitting power from the power house to the point of junction with the distribution system or with an interconnected primary transmission system, all miscellaneous structures used and useful in

connection with such unit, or any part therof, and all water rights, rights of way, ditches, dams, reservoirs, lands or interest in lands, the use and occupancy of which are necessary or appropriate in the construction, maintenance, and operation of such unit.

The term "water supply project" means a complete unit of improvement or development for the procuring or supply, or both, of water, which is not a power project as hereinbefore defined, consisting of a water supply dam or change in stream for water supply, or both, for which a limited water supply permit at any time is being sought or has been granted, a reservoir, the dam and other works appurtenant thereto, and all primary water conduits leading immediately therefrom to the point of junction with the distribution system or with an interconnected primary water conduit, and all water rights, rights of way, ditches, dams, reservoirs, and lands or interests in lands, the use and occupancy of which is necessary or appropriate in the construction, maintenance, and operation of such unit.

The term "permittee" means the holder of a limited power permit or a limited water supply permit, and his heirs, successors, and assigns.

The term "navigable waters of the United States" means those parts of streams or other bodies of water over which Congress has jurisdiction under its authority to regulate commerce with foreign nations and among the several States, and which, either in their natural or improved conditions, notwithstanding interruptions between the navigable parts of such streams or waters by falls, shallows, or rapids, compelling land carriage, are used, or suitable for use, for the transportation of persons or property in interstate or foreign commerce, including therein all such interrupting falls, shallows, or rapids, together with such other parts of streams as shall have been authorized by Congress for improvement by the United States, or shall have been recommended to Congress for such improvement after investigation under its authority.

Section 2. A power dam or change in stream to develop power shall be deemed to be within the jurisdiction of the United States, within the meaning of this section, whenever (1) such dam or change is constructed or made, or to be constructed or made, in or upon navigable waters of the United States, or (2) the Federal Power Commission shall have found that the interests of interstate or foreign commerce would be affected by the construction of such dam or the making of such change.

Every permit hereafter granted by the commission for the construction of a power dam or for a change in stream to develop power, not within the jurisdiction of the United States, shall be limited to such periods not exceeding fifty years as the said commission shall determine and set forth therein: Provided, That the permittee shall be entitled to extension and renewal of such permit upon the terms thereof until the permittee shall have received through recapture or purchase by the Commonwealth, or by a duly authorized subsequent permittee, repayment of the capital prudently invested in the power project upon the faith of the permit, plus such reasonable damages, if any, to property of the permittee valuable, serviceable, and dependent for its usefulness upon the continuance of such permit, but not recaptured or purchased, as may be caused by the severance therefrom of property taken.

Every permit hereafter granted by the commission for the construction of a power dam or for a change in stream to develop power, within the jurisdiction of the United States, shall be on the following conditions, which shall be expressed in such permit, namely: (a) That the permit shall become null and void unless, within the time specified therein, the permittee (or, as to a change in stream within the Commonwealth effected or to be effected by a dam or other means without the Commonwealth, those constructing or purposing to construct, maintain, or operate such dam or other means) shall secure from the Federal Power Commission a license for such dam or change; and (b) that if and to the extent that any of the rights or powers set forth or reserved as rights or powers of the United States in or pursuant to the provisions of such license shall be waived by the United States or be unenforceable by the United States, then and to that extent such rights and powers (including, if so waived or unenforceable, any rights of recapture, extension, or renewal so set forth or reserved) may be exercised and enforced by the Commonwealth of Pennsylvania, subject to such alterations in plans, specifications, or structures, and such extensions of time for commencing or completing construction, as may be made or granted by the Federal Power Commission.

Every permit granted under this section shall be subject to such reasonable annual charge, specified therein, as the commission shall fix, for the purpose of reimbursing the Commonwealth for the costs of administration of this act, and may, in the discretion of the commission, embody such other terms, conditions, and stipulations as the commission shall deem necessary to protect the present and future interests of the Commonwealth and its people in the construction, maintenance, and operation of the project, and in the water and power resources to be utilized thereby, and suitable to secure to the permittee a reasonable opportunity for a fair return on the actual investment prudently made in the project.

Section 3. The commission in granting every limited water supply permit shall specify a reasonable annual charge, in an amount fixed by the commission, to be paid by the permittee for the purpose of reimbursing the Commonwealth for the cost of administration of this act, and the commission shall embody therein such other terms, conditions, and stipulations as the commission shall deem necessary and proper to protect the present and future interests of the Commonwealth and its people in the construction, maintentnce, and operation of the project and in the water resources to be utilized thereby.

Section 4. It shall be unlawful for any corporation or natural person to use for the development of water power, or for the main purpose of storing, cooling, diverting, and using, or any of them, water for steam raising or steam condensation, or both, in the generation of electric energy for use in public service, any dam constructed under any permit hereafter issued otherwise than under section two of this act, or to divert or use for said purposes, or for said main purpose, any stream or body of water the course, current, or cross-section of which shall have been changed or diminished at the point of diversion, or use, under any permit hereafter granted, otherwise than under section two of this act.

Section 5. Any permittee holding a permit granted under section two

of this act may, with the consent of the commission, which consent may be set forth in such permit, overflow, submerge, occupy, and use, as appurtenant to the power project in behalf of which such permit is granted, and subject to the terms, stipulations, and conditions expressed therein, any island owned by the Commonwealth in the river Susquehanna, or any of its branches, or in any other stream or water over which the commission has jurisdiction.

Section 6. The provisions of this act shall not be construed as affecting any permit or authority heretofore granted or given pursuant to law for the construction of any dam, or for the changing or diminution of the course, current, or cross-section of any stream or body of water; but the holder of any such permit or authority may apply for a limited power permit or a limited water supply permit under this act, and, if and when such applicant is granted the same, he shall have all the rights and be subject to all the duties conferred or imposed by or under this act.

Section 7. The commission is hereby authorized and empowered to make such rules and regulations, and issue such orders, as may be necessary and proper for carrying out the provisions of this act.

Section 8. The Attorney General may, on the request of the commission, institute proceedings in any court now or hereafter by law clothed with jurisdiction in civil cases in which the Commonwealth is a party for the purpose of remedying or correcting, by injunction, mandamus, or other process, any action of commission or omission in violation of the provisions of this act, or of the terms, conditions, or stipulations of any limited power permit or limited water supply permit granted hereunder, or of any lawful regulation or order promulgated hereunder. In the event of the failure of any permittee to comply with the requirements of any final decree in any such proceedings, the Attorney General may institute proceedings for the purpose of revoking the permit. The said courts shall have jurisdiction over all the above-mentioned proceedings, and shall have power to issue and execute all necessary process, and to make and enforce all rights, orders, and decrees to compel compliance with the lawful orders and regulations of the commission in respect of any so permitted dam or appurtenant works, and in respect of any so permitted change or diminution of the course, current, or cross-section of any stream or body of water, and to compel the performance of any condition imposed under the provisions of this act. In the event a decree revoking a permit is entered, the court is empowered to sell the whole or any part of the dam,together with any or all works, lands, and water rights appurtenant thereto or existing under the permit, to wind up the business of such permittee conducted in connection with such dam, change, or diminution, to distribute the proceeds to the parties entitled to the same, and to make and enforce such further orders and decrees as equity and justice may require. At such sale or sales, the vendee shall take the rights and privileges belonging to the permittee, and shall perform the duties of such permittee and assume all outstanding obligations and liabilities of the permittee which the court may deem equitable in the premises.

Section 9. Nothing in this act shall be construed to deprive the Public

Service Commission of the Commonwealth of Pennsylvania of any jurisdiction, powers, or duties now vested in it by the laws of the Commonwealth.

Section 10. The right to amend and repeal this act is hereby expressly reserved, but no such alteration, amendment, or repeal shall effect any permit theretofore issued under the provisions of this act, or the rights of any permittee thereunder.

Section 11. All acts and parts of acts inconsistent with this act are hereby repealed.

APPROVED—The 14th day of June, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 294.

CLYDE L. KING,
Secretary of the Commonwealth.

No. 250

AN ACT

Authorizing the Department of Forestry, with the approval of the Governor and Attorney General, to lease for periods of not more than fifty years, on terms, conditions, and stipulations expressed in each lease, any portions of the State forests for dams, reservoirs, canals, pipe lines and other water conduits, power houses and transmission lines, for the development of water power, for steam raising and condensation, and for the generation and transmission of electric energy.

Section 1. Be it enacted, &c., That the Department of Forestry, with the approval of the Governor and Attorney General, is hereby authorized, in its discretion, to lease for periods of not more than fifty years any portions of the State forests for use as sites for dams and other water obstructions, reservoirs, canals, pipe lines, and/or other water conduits, for the purpose of the development of water power and/or for the main purpose of storage, conveyance, and/or cooling of water for steam raising and/or steam condensation in the generation of electric energy for public service, and/or for use as sites for power houses and/or transmission lines for the generation and transmission of electric energy. Every such lease shall be on such terms, conditions, and stipulations, expressed in each lease, as the department with the approval of the Governor and Attorney General, shall deem necessary for the protection of the present and future interests of the Commonwealth and its people and suitable for affording a reasonable opportunity for a fair return on the actual investment prudently made on the faith of such lease, which may include provisions not repugnant to the rights of the United States, its permittees, licensees, or transferees, existing at the time of the making of such lease, reserving an option in the Commonwealth to renew or extend for not more than fifty (50) years such lease, or to take over the project works, by and for itself or by and for another prospective lessee, upon payment by the Commonwealth or by such other prospective lessee of the actual net investment in the project works, by which is meant a complete unit of improvement or development consisting of a power house and appurtenant works, all

water conduits, all dams and works appurtenant thereto which are a part of said unit, and all storage, diverting, or forebay reservoirs directly connected therewith, the primary line or lines transmitting power from the power house to the point of junction with the distribution system or with an interconnected primary transmission system, all miscellaneous structures used and useful in connection with such unit or part thereof, and all water rights, rights of way, ditches, dams, reservoirs, lands, or interest in lands, the use and occupancy of which are necessary or appropriate in the maintenance and operation of such unit.

APPROVED—The 28th day of May, A. D. 1923.

GIFFORD PINCHOT.

The foregoing is a true and correct copy of the Act of the General Assembly No. 250.

CLYDE L. KING,
Secretary of the Commonwealth.

IX. APPENDIX TO REPORT ON PRETREATMENT OF BITUMINOUS COAL

BY JUDSON C. DICKERMAN

Notes on location and description of Coal Carbonization By-Product Recovery Plants with a brief discussion of underlying principles governing such processes.

All the bituminous, sub-bituminous, and lignite coals are possible material for coal carbonization plants. However, those coals which have the double properties of forming a good coke and of yielding large volumes of combustible volatile matter are normally the most economic to treat for recovery of by-products. For such practical considerations, it will not normally pay to attempt to recover by-products when cooking semi-bituminous coals containing merely 12% to 16% or 18% of volatile matters, tho such coals sometimes make a most excellent coke. The low volatile bituminous coals are frequently mixed with other very high volatile coals, and on carbonizing the mixture, the volatile components are recovered. This is done to get certain desired properties in the coke produced.

Coals, which, upon heating, more or less melt or become pasty and swell, form coherent coke. They present a difficult mechanical problem when treated in retorts in which the coal mass is more or less stirred or tumbled about, since the sticky mass as it hardens, adheres tenaciously to the walls of the retort, and to stirrer arms, if any, tending to plug up the retort and to retard the transmission of heat to the fresh coal.

Non-coking coals present no serious mechanical difficulties in carbonizing when in motion, but the solid residue or coke is in a more or less finely divided condition, practically impossible to burn efficiently except it is made

into briquets or unless ground still finer and used thru powdered fuel burners.

The process and therefore the equipment to be used in a coal carbonizing operation depends upon which product is most desired. While all by-product recovery processes will yield several products, no one process will result in maximum yields of best quality of even two of the more important products. When dense, strong, coke is wanted for metallurgical furnaces, the yield of oils and tars is small. When the largest possible volumes of combustible gases are wanted, the coke is somewhat less desirable and the oils are low in quantity and quality. When large yields of tar oils are wanted, the coke produced is friable, soft, and often too fine to be burned on ordinary grates.

Carbonization retorts may be classed according to manner of charging and discharging, as

(a) Intermittent, in which the coal is charged into the empty retort and remains there undisturbed until carbonization is completed, when the whole mass of coke is discharged at one time.

(b) Continuous charging and discharging, so that the retort contains at any one time, fresh raw coal, partly, and completely carbonized material. The charging and discharging may be actually continuous or they may be accomplished with slightly larger amounts at relatively short intervals of time.

When the solid product is wanted in a firm and lumpy condition, the best results are obtained with the oven type of retort. When the largest possible output, without much regard to the physical condition of the coke, is wanted, the continuous type of retort, represented by the cylinder or shaft type of construction, meets this requirement.

Retorts may also be classified as:

(1) Oven type
(2) Shaft type
(3) Cylinder type, horizontal or inclined.

Retorts may be still further classified as:

(a) Externally heated
(b) Internally heated.

Upon heating bituminous coal in a retort thru an ascending range of temperatures, a marked change in the quantity and characteristics of evolved vapors and gases is noted to begin at between 600° and 700°C. (1112° to 1292°Fah.). At low temperatures between 500° and 600°C the vapors evolved are rich in oils and tars, and the gas has a high heating value, but the ammonia evolved is rather small, perhaps equivalent to 8 or 10 lbs. of ammonia sulphate per ton of coal treated.

At temperatures notably above 800° Cent., the evolved vapors undergo additional decomposition. The oils and light tars of low temperature distillation are converted to permanent gases, to hydro-carbons of the benzene ring type, and to viscous heavy tars. It is well recognized that the imminent decline in the supply of petroleum will create a demand for the petroleum-like oils of low temperature carbonization of bituminous coal.

Likewise the increasing inability of the available sources of natural gas to meet the demands for gaseous fuel is creating a rapidly broadening market for gas obtained from coal. The fuel consuming public is not going to relinquish the convenience and perfection of performance which are obtainable from gas and oil fuels until every possibility of meeting such demands from by-products of bituminous coal is exhausted.

In processing bituminous coal for fuel for power plants, it is essential to utilize a process which will yield relatively large quantities of those products which have a higher market value than the raw coal, unit for unit, while generating power with the less valuable products. The process used must represent sufficiently low investment and operating costs so that the cost of the carbonized fuel per unit of power developed, giving due credit for any capital or operating savings accompanying its use and also for the value of the by-products, may not exceed the cost of the equivalent unit of power produced from any raw fuel available.

There are two distinct principles represented in the processes which are now being installed or already operating in connection with power plants. In one, the power plant fuel consists of the solid carbonized residue. In the second, all or nearly all of the original solid fuel is converted into gas and vapors, the condensible vapors removed, and the permanent gases burned as the power plant fuel.

When the carbonized solid residue furnishes the fuel supply, it is desirable that the residue shall be as friable and non-gritty as possible, on the basis that the most efficient known method of generating power in very large quantities is by the use of powdered fuel under steam boilers supplying steam turbines direct connected to electric generators. Low grade residues from processes yielding hard and gritty coke involve higher costs for pulverizing, but they may be used when charged in at prices sufficiently low to justify their use.

In the second or gasification processes, we as yet have to consider that the gas fuel must be burned under steam boilers. Undoubtedly, a btu. brought to the boiler in gas form, can be converted into steam with somewhat greater efficiency and less expense than a btu. supplied to the boiler either as solid or powdered fuel. It is also well known that clean gas can be burned directly in internal combustion engines to yield power at many less btu's. per kwh. than can be obtained through steam engines or turbines. But internal combustion engines are practically limited in maxima to about 5000 h. p. per unit, with installation and maintenance costs, compared with those of 50,000 to 75,000 h. p. steam turbo-generators, that are prohibitive. Considerable work has been done in developing a gas turbine, but so far, it seems still below the horizon of the near future. Prof. W. Schule quoted in "Motorship," May 1922, and H. Schmolke, in "Mechanical Engineering," March, 1922, state that thermodynamically a gas turbine should show efficiencies above those of gas piston engines or between 40% and 50%. There is therefore a future possibility which furnishes an added interest in the development of gasification processes for power plant purposes.

The outstanding processes of the first or solid residue class are, in America:

(1) The Piron-Caracristi process, adopted by the Ford Motor Company for a 400 tons a day plant, erected in Walkerville, Canada, in 1924, and a 4000 ton plant at the River Rouge plant, Detroit, Mich., whose construction was started in 1924.

The most complete description of the Piron-Caracristi process as applied to Power Plant Practice is given in "Power," May 29, 1923. In brief, this process applies the following principles of practice.

The crushed coal is charged into a series of shallow pans 36″ x 18″ x 1″ thick, which are part of a continuous chain belt. The coal layer is about ⅝″ deep. During the carbonization period, the coal particles do not move in relation to each other, but are free to swell, become pasty, and dry into a sheet of coke, which detaches itself from the pan during the return travel of the belt.

The heat is applied to the coal through a melted lead bath on the surface of which the pans float and are dragged along from one end of the bath to the other. The bath's temperature is maintained by burning gas or oil in flues, lining the bottom and sides of the clay refractories tank containing the lead. As the temperature of the lead can be readily ascertained and controlled, the coal is subjected to a uniform, definite temperature through the transfer of heat from lead to iron pan, thence, to the thin layers of coal in the pans.

The volatile matter evolved escapes to the condensers through ducts in the wall of the distillation chamber over the lead bath, without being subjected to possibly higher temperatures than were intended.

While the quantity of coal in each pan is small, the time necessary to allow for satisfactory carbonization of the thin layer of coal is short, less than 5 minutes is the claim, so that the furnace as a whole may have a large daily output. As designed, each unit of 8 conveyors, is to handle 500 tons of coal per 24 hours.

Some of the problems of this process are (1) Operating a chain drive within an airtight chamber at 1200° Fah.; (2) Maintaining an atmosphere in contact with the lead bath that will prevent formation of lead oxide thereon; (3) Feeding coal regularly in uniform layers into the pans without scattering onto the lead bath; (4) Discharge of the lumpy, porous coke from the distillation chamber without admitting air to the retort; (5) Holding molten lead in a clay refractories furnace of approximately 50′ x 14′.

Some preliminary operations at Walkerville showed that all details of design had not been worked out satisfactorily. Our latest information is that the plant as modified is expected to be put in operation about the first of January, 1925.

(2) The Smith, or Carbocoal process, for which a 500 tons a day plant was erected in 1918-1919 at Clinchfield, Va. This plant was faulty in design and was shut down in 1922, but further investigations on a large scale experimental retort have been carried along at Fairmont, W. Va., by the Consolidation Coal Products Company, a subsidiary of the Consolidation Coal Company, 67 Wall Street, New York, until at the present time, it would appear that the mechanical defects of the Clinchfield plant, as far as the

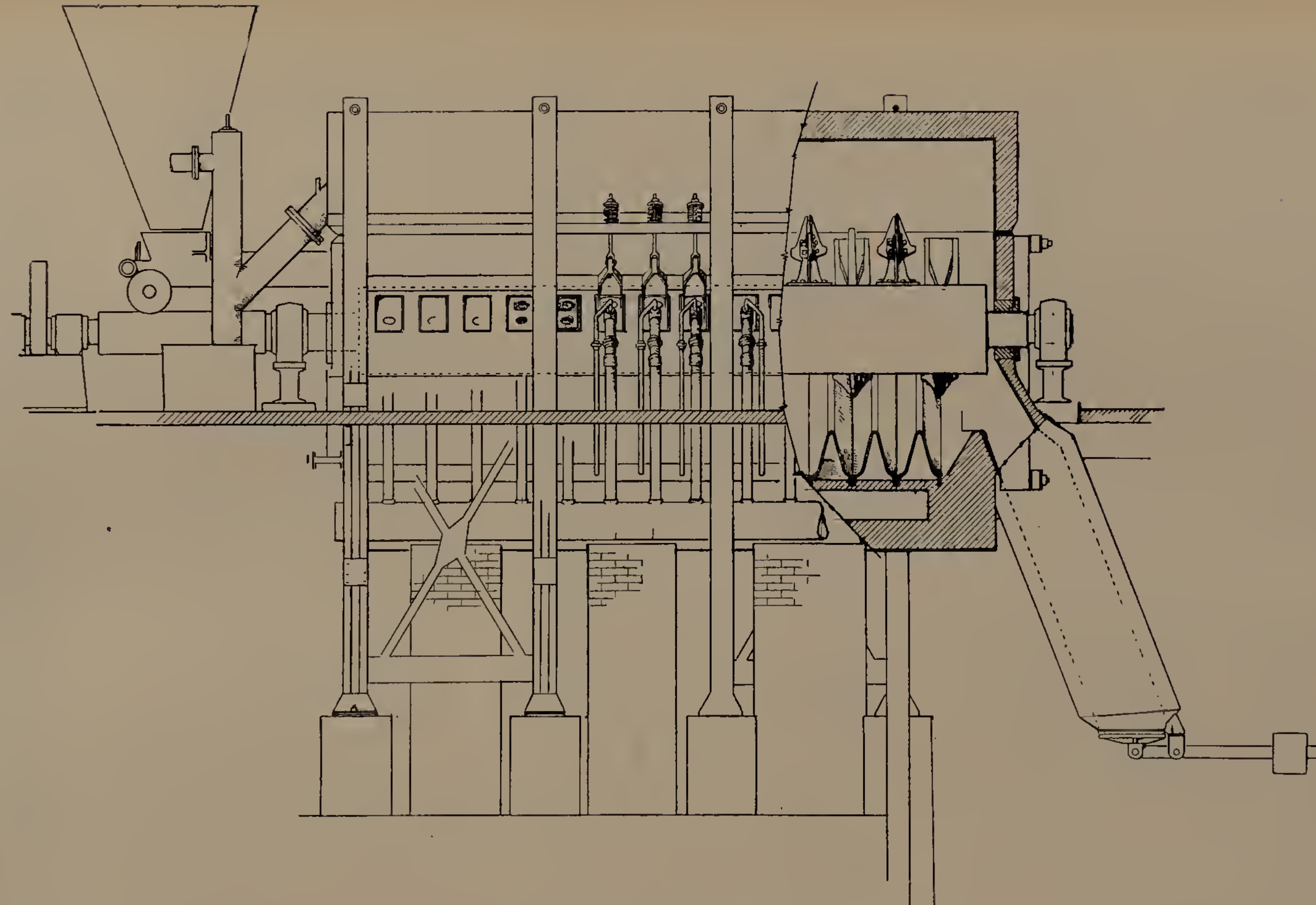

FIG. 1-A. SIDE ELEVATOR

LOW TEMPERATURE COAL CARBONIZING RETORT

(Development of the Smith or Carbocoal retort) Consolidation Coal Products Company, Coverdale and Colpitts, Consulting Engineers, Charles V. McIntire, Engineer in charge.

Capacity as operated at Fairmont, W. Va., in the fall of 1924, 50 tons of coal per 24 hours.

Externally heated by gas, internally agitated by stirrer arms, continuously fed and discharged, metal heating surfaces.

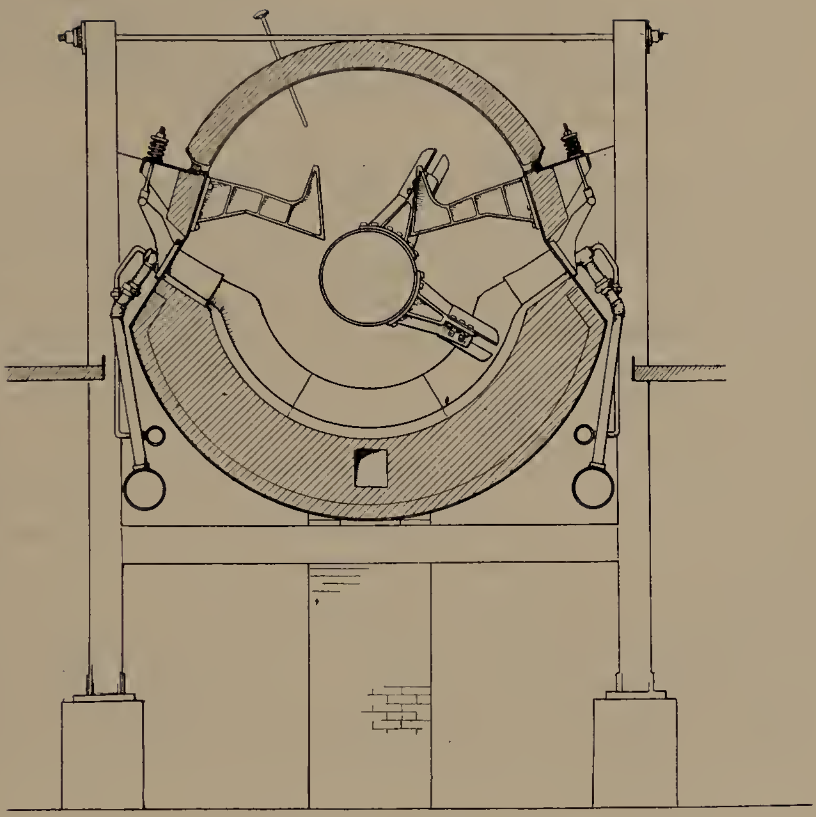

FIG. 1-B. END ELEVATION

low temperature carbonizing equipment was concerned, have been successfully overcome; 50 tons of coal per day are being put through the retort.

The feature in the Carbocoal or Smith process of main interest to power plant operation is the low temperature carbonizing retort. As successfully worked for over three months at Fairmont, W. Va., under the direct supervision of Mr. C. V. McIntire*, with Messrs. Coverdale & Colpitts, 66 Broadway, New York, as Consulting Engineers, the retort consists of the structure shown in the figures 1-A and 1-B.

The retort may be classified as a stationary, horizontal, externally heated, internally agitated, low temperature furnace—cylindrical in form. It is 16′ 3″ long by 8′ 6″ diam.

It contains an agitator shaft which oscillates through an arc of about 270°, carrying arms with paddles which move through the mass of coal, and close to the heated surface. Experiment indicates as satisfactory a speed of oscillation such that the coal is moved every 30 seconds.

*Mr. McIntire, a trained Mechanical Engineer, had many years of experience in the design, erection and operation of standard by-product coke ovens before undertaking the further development of the Smith retort.

The lower part of the retort consists of modified V or U shaped grooved sections of special resistant iron fitted together, with flanges to break joints. The upper part is a portion of a cylinder, built of light boiler plate covered with sil-o-cel, which can be lifted bodily off the lower half for access to the shaft and paddles and inside of the metal sections.

The metal sections are heated from below by burning gas, which may be producer gas. Regenerators could be used if desired, or the heat of the escaping products of combustion could be recovered in a boiler setting. The coal in slack form, is fed continuously into one end of the retort. It softens under the influence of the heat and carbonizes, becoming finally at the end of the retort a fine soft coke, which is discharged in a black state continuously into a hopper, from which it is drawn at intervals into cars below. Steam is blown into a hopper which serves to cool the coke a little. It is found necessary to further quench or cool the coke by spraying thoroughly with water. The semi coke is discharged in particles too small to be used on ordinary grates. It is, however, much less gritty than high temperature coke. It can be produced so cheaply that the market would probably absorb at a price to yield a dollar a ton profit, large amounts of briquets. The briquets would furnish a much better fuel than ordinary coke and for many purposes would soon be preferred over anthracite. The briquets would be easily ignited and burn smokelessly. It does not appear likely that this process will produce directly from the retort, when operated for best all around efficiency, semi-coke in physical condition to market for domestic purposes. Its final distribution should be either as powdered fuel or as briquets.

The gases and vapors evolved containing oil, tar, ammonia and permanent gases leave the retort by a pipe at the coal inlet end. Therefore, the rich gasses first evolved are for the shortest possible time in contact with heated coal or surfaces. The gases and vapors go to the usual system of condensers, scrubbers, etc., to remove and recover the oils, tars and ammonia. The permanent gases are available for storage and subsequent sale or use in heating the retort.

The temperatures of distillation are maintained at 1200° F. on the coal side of the heating flues, and at 650° to 750° F. in the gas space above the coal. The coal never exceeds 800° F. in its travel through the retort except possibly for 30 seconds at a time for those particles which lie against the 1200° F. flue surface. The distillates are therefore practically genuine low temperature products, a result not experienced in many other processes. It probably would be feasible to force the temperature higher at the coke exit end, but nothing of value would be gained, since the really valuable by-products have already been driven out, the 10-12% of volatile matter left in the coke yielding light gases. Higher temperatures would also tend to make the coke harder and more gritty, increasing the expense of pulverising.

Using high volatile Fairmont coal, the yields of products per net ton, are about as follows:

Ammonia as Ammonium Sulphate 10 lbs, @ 2.5¢/lb.	0.25
Tar crude, 28 gals. @ 7.0¢	1.96
1000 cu. ft. surplus gas @ 25¢/M	.25
1500 lb. coke, (equivalent of $2.00 ton coal) @ $1.90/ton	1.42
	$3.88

The costs of operation on a large plant to handle 8000 tons a day, would be on a daily basis.

Investment charges, interest, depreciation and taxes @ 15%, on plant cost of $800.00/ton daily capacity	$2630.00
Operating charges, labor, maintenance & supplies at 70¢ a ton	5600.00
Miscellaneous and overheads @ 10¢/ton	800.00
8000 tons coal @ $2.00/ton	16000.00
Total for 8000 tons	$25030.00
Or, per ton	3.14
Profit per ton	.74
Profit per ton a day on 8000 tons	$5920.00

In spite of an as yet undeveloped market for low temperature tars, one producer is selling his product at 7¢ and another at 6¢ per gallon. The crude tar from one ton of coal will refine to produce about 5.5 gals. of tar acids which contain much cresol, 1.7 gals. motor gasoline, 8 gals. of neutral oil, and 12 gals. of pitch. Due to the 40% or more content of tar acid oils of marked value for preservatives and for important chemical manufacture the value of these tars will probably increase to approximately 10¢ a gal.

By the substitution of producer gas as fuel for the retorts, a net gain of from 10 to 25¢ for gas sold could be realized. The gas evolved is of high heating value, from 800 to 900 btu./cu. ft. The yield of gas is from 3000 to 3500 cu. ft. This gas should mix well with natural gas, or with leaner gases from water gas producers or high temperatures coke ovens, as an enricher.

Because of the smaller volumes of gas to be dealt with, the piping, condensers and gas storage tanks may be considerably smaller than in a high temperature process, with consequently less installation and operating costs. The capacity of a retort is fully double that of the best coke ovens, but should not cost much more than a high grade oven.

The prevailing estimates of practically all the low temperature carbonizing processes are about $600.00 investment per ton of daily capacity, against known figures for standard by-product coke ovens of $1800 to $2400 per ton of daily capacity.

With the successful solution of the one serious mechanical problem of overcoming the effects of the pasty or fused mass, which the writer from personal observation and later information believes has been accomplished in the McIntire retort, it would seem that an economically possible low temperature process is now available for power plant use.

Considerable variation in prices or costs could take place without wiping out the margin of profit. Of course, any large scale operation would have its

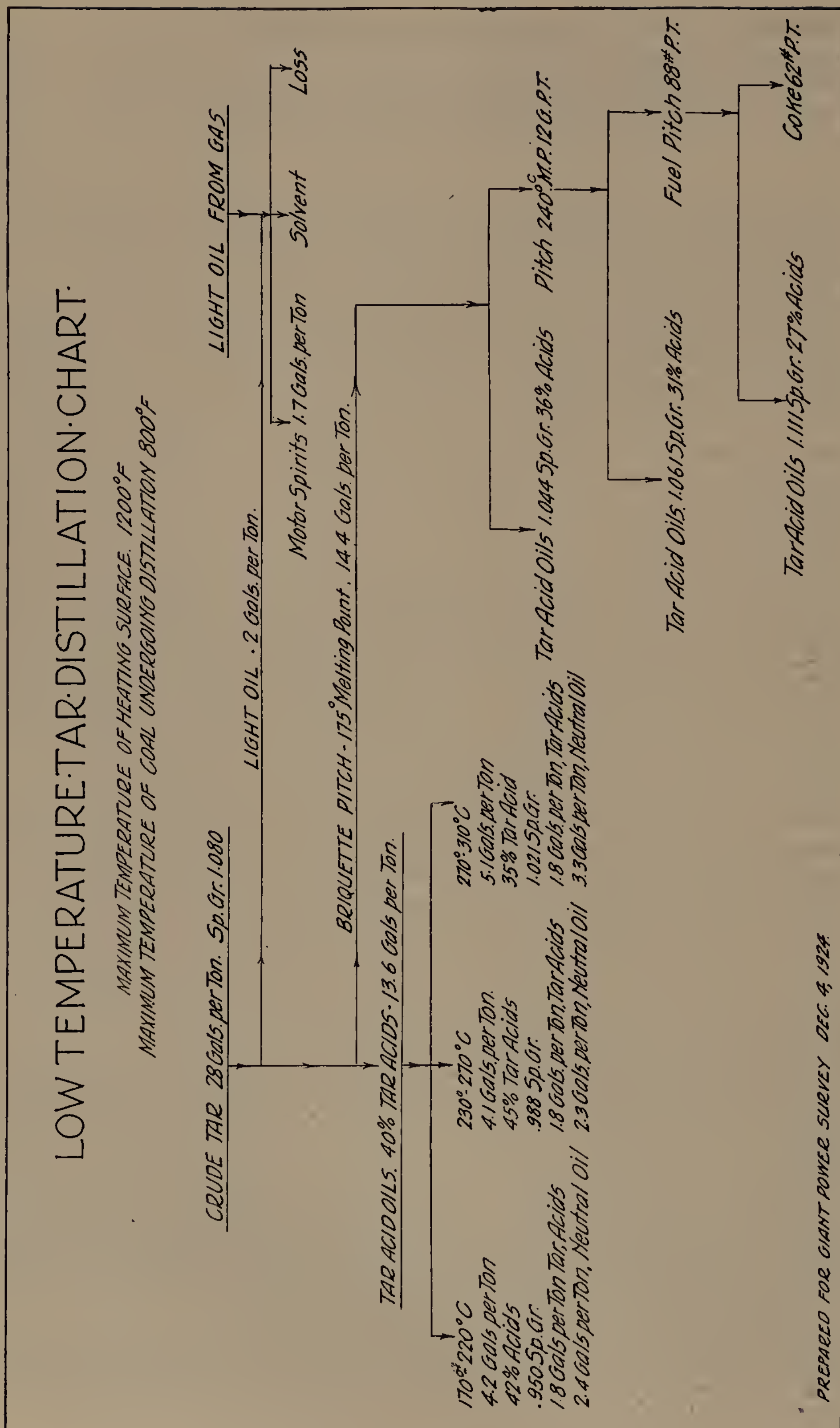
LOW TEMPERATURE·TAR·DISTILLATION·CHART·
MAXIMUM TEMPERATURE OF HEATING SURFACE. 1200°F
MAXIMUM TEMPERATURE OF COAL UNDERGOING DISTILLATION 800°F
CRUDE TAR 28 Gals.per Ton. Sp.Gr. 1.080
LIGHT OIL FROM GAS
LIGHT OIL · 2 Gals. per Ton.
Motor Spirits 1.7 Gals. per Ton
Solvent
Loss
BRIQUETTE PITCH - 175° Melting Point . 14.4 Gals. per Ton.
TAR ACID OILS. 40% TAR ACIDS · 13.6 Gals per Ton.
170°-220°C
4.2 Gals per Ton
42% Acids
.950 Sp.Gr.
1.8 Gals per Ton Tar Acids
2.4 Gals per Ton, Neutral Oil
230°-270°C
4.1 Gals. per Ton.
45% Tar Acids
.988 Sp.Gr.
1.8 Gals. per Ton, Tar Acids
2.3 Gals. per Ton, Neutral Oil
270°-310°C
5.1 Gals. per Ton
35% Tar Acid
1.021 Sp.Gr.
1.8 Gals. per Ton, Tar Acids
3.3 Gals per Ton, Neutral Oil
Tar Acid Oils 1.044 Sp.Gr. 36% Acids
Pitch 240°C M.P. 12 G.P.T.
Tar Acid Oils 1.061 Sp.Gr. 31% Acids
Fuel Pitch 88# P.T.
Tar Acid Oils 1.111 Sp.Gr. 27% Acids
Coke 62# P.T.
PREPARED FOR GIANT POWER SURVEY DEC. 4, 1924.

FIG. 2

initial difficulties, minor engineering details are to be worked out; but the compactness, simplicity, and effectiveness of this process make it appear highly favorable.

The Carbocite Company, Canton, Ohio, Clarence B. Wisner, vice-president and developer of the process, proposes to apply a discovery that pasty, coking coals, if preheated in the presence of air at temperatures below the melting point, which is also below the point of evolution of volatile products other than water, will become non-coking and non-pasty, when later heated to higher temperatures with the exclusion of air. We are not aware that this process as yet has been given full sized demonstration nor that it is adopted for power plant purposes, though we do know it has been studied by interested power producers.

The outstanding commercial installation representative of by-product complete gasification processes is that of the Combustion Utilities Corporation, sometimes called the Doherty process. A commercial plant was put in operation at the Hazel-Atlas Glass factory at Washington, Pa., in the summer of 1924, following years of experimental plants in Denver, Col. and Toledo, O. The plant at Washington, Pa., was visited by the writer a few weeks after it was put in operation. It was not possible for the writer to get as definite a personal impression of its success as with the Fairmont plant. The operations, from the nature of the process were less open to perception and more dependent upon overall results. The plant was apparently well built. The main problem of this type of process is to overcome the binding or sticking of the charge of caking coal within the retort, which has been a major source of trouble in all gas producers attempting large production with our eastern melting bituminous coals.

The retort may be classed as of the vertical stack, internally heated, continuous operation, semi-combustion, gasification type, with recovery of tars and ammonia, producting large volumes of low btu. gas of about 160-210 btu. As constructed the stack is about 100 feet high, and about 26 feet outside diameter at the base.

High volatile bituminous coal, crushed and mixed with a proportion of coke sufficient to keep the mass from becoming too pasty at any stage of the process, is charged continuously. A controlled air blast enters a few feet above the bottom. Pre-heating the air blast increases the rate of formation and especially the heating value of the gas. A portion of the coked charge, accompanied with ash is withdrawn at frequent intervals at the bottom. The coke is screened and washed to separate it from the ash. The coke comes out in small pieces from nut size down to small granules. The coke is used to mix with raw coal to be charged again into the retort at the top.

The retort can be so operated that less but richer gas is obtained, up to about 300 btu./cu. ft., and a larger proportion of coke is withdrawn, so that some becomes available for sale.

The hot producer gas from above the combustion zone passing thru the column of descending coal, distills off the volatile matters, carrying them along with the producer gas, which is passed through suitable condensers where the tars and oils are removed, and the gas cleaned from dust and

tarry matter. The tars and oils obtained are essentially low temperature distillation products.

The Superintendent of the plant explained that the capacity of the stack had not been reached when the capacity of the condensing and gas cleaning devices installed had been reached. With large capacity the high velocity of the gases required special precautions in removing dust and atomized tar, when the gas was to be used in glass or other furnaces requiring clean gas. Refinements in cleaning the gas would not be necessary when the gas was to be burned under steam boilers.

From a power plant standpoint, this process offers a means of recovering by-products from the fuel used; permits of the use of almost any grade of combustible material, and of operation at varying rates of production, producing coke for sale when the demand for power gas is light; furnishes a fuel gas requiring the simplest type of boiler furnace, and which can be burned with thermal efficiency not possible to equal with solid or liquid fuels. If and when the gas turbine becomes available, it would be the ideal method to use.

It is claimed that the investment cost is approximately $1000.00 per ton of daily capacity, operating costs, maintenance and supplies approximately 75 cents per ton and that the cash value of the by-products, for a plant located in the mining region should equal about 50% of the cost of the coal.

Due to the very large volume of gas to be handled, the piping and condensing system must be very large, relatively cumbersome. With the limited data available for comparison it would appear that the attractiveness of this process applied to power plant operation is somewhat less than that of the true distillation processes but its probabilities would be worth considering in any particular case.

An experimental plant of about 25 tons a day capacity designed by the late C. C. Bussey, has been operating near Louisville, Kentucky. It is a shaft type, continuously operated, internal, partial combustion process, in principle, the same as the plant at Washington. We are informed a plant with a capacity of 500 tons of coal a day is being installed for a glass works. The special feature of this process is the production of considerable coke for sale, which is presumed to add to the profitableness of the operation. The liquid by-products are presumably of low temperature distillation characteristics.

The installation costs are claimed to be about $600 per ton of daily capacity, with operating and capital costs of about $1.00 per ton, exclusive of the cost of coal.

In Great Britain, the MacLauren process is being installed at the Dalmarnock Power Station of the Glasgow, (Scotland) Corporation. This process utilizes a vertical shaft, 45′ high by 8′ square internally. An air blast enters thru ports several feet above the bottom of the retort. Steam enters at the bottom, serving to cool the coke which has passed through the zone of combustion.

The fundamental principals of operation are the same as in the Doherty process. It can be run either to deliver some coke for sale or for complete gasification. The liquid condensates and other by-products are low tempera-

ture products. The shape and manner of operating the producer seem to have overcome the troubles usually encountered in handling caking coals. It is expected that this process will be successful as applied to power plant use, as the investment and operating charges are said to be very low.

One of the most often referred-to low temperature processes is that of the socalled "Coalite" process, which has operated more or less commercially at Barugh, Barnsley, Great Britain. Many types of retorts have been used, all being modifications of the oven type, in which the coal mass remains undisturbed during the progress of carbonization. Millions of dollars have been spent. The primary object of all these efforts was to obtain a solid fuel which could be marketed for domestic purposes, with the expectation that its smokeless property, combined with ease of kindling, and efficiency in use, would enable it to command a higher price than raw coal.

It was essential therefore that the semi-coke produced be physically as dense and strong as possible. Only a moderate measure of success seems to have followed the endeavor. For power plant purposes there appears to be little of real interest, as the retorts are costly and cannot be of large capacity. In the opinion of the writer the low temperature oven type has little promise for power plant purposes.

There are hosts of other processes which have been patented and in some cases large scale experimental plants have been operated, but they are all modifications of the systems so far described. With non-coking coals, the problem is largely one of cheap quantity handling, and marketing the by-products. With the rich coking coals such as prevail in Pennsylvania, there exists the problem of handling satisfactorily the coal in its plastic state. This appears to have been overcome in some of the processes described above.

There is bound to be an insistent growing demand for fuel gas. Natural gas is failing. Low grade gases, such as are produced in the internally heated, partial combustion processes cannot be economically stored or pumped long distances, as compared with richer coal gases. The writer is impressed with the idea that the future calls for the maximum possible production of medium to high grade coal gases, from 550 to 800 btu., to be distributed thru natural gas mains and thru new mains which may extend even to Philadelphia, serving smaller towns on the way. Looked at from the independent and isolated position of a Philadelphia gas plant, required to purchase a right of way, install and operate pumping stations, and other costs of transmission without sharing any of these costs with allied industries, the costs would be above the present freight costs assignable to the coal carried by rail to Philadelphia. But present freight rates are in part based on original low costs of building the railroads. Increased facilities at the new high costs may compel upward readjustments of freight rates on coal.

On the other hand, the State is bound to be crossed by great electric transmission lines, involving rights of way and sub-station locations and operations which might well be shared with gas transmission line operations. Possibly existing oil line rights of way or even public highway routes could be utilized with great savings. We must not think of the not distant future in terms of the facilities of today.

Some of the important problems of the future directly related to the methods to be adopted in handling the bituminous coals in Pennsylvania are:

(1) Removing from the railroads such freight as can be economically handled otherwise, which means transporting supplies of heat and power by wire and pipe lines;
(2) Supplying heat under most efficient labor saving and cleanly conditions, which is by gas and oil for smaller operations and powdered smokeless fuel for large operations. These can be produced and prepared under mass production conditions at the coal mines, in connection with Giant Electric Power Plants.
(3) Supplies of oil for mobile engines, creosotes for preservatives and disinfectants, tars for water proofing, road building, etc., ammonia for fertilizer and chemical manufacture, hydro-carbons for conversion into dyes, explosives, etc.
(4) Making the maximum use of existing facilities, by combining rights of way for roads, power lines, gas and oil lines, telegraph and telephone lines; combining their supervision and operation.

The map (Figure 3) showing the routes of the principal oil pipe lines traversing the State of Pennsylvania is presented as illustrating the rights of way acquired by the petroleum industry in moving its products from the producing sections to the great tide water refineries and shipping ports at Baltimore, Marcus Hook, Philadelphia and Bayonne. Especially interesting from the standpoint of transmitting electric power and by-product coal gas from the region where Giant Power stations could be best located, are the Tuscarora and the Crescent pipe lines. These rights of way may be assumed to have been chosen to give the best practical direct routes to the southeastern part of the State. They pass through the regions of densest population with its intensive development of industry. Utilizing these rights of way, a joint organization transmitting oil, gas, and electric power should reduce the transmission and operating costs of each industry very materially. Electric power substations and oil and gas pumping stations could be jointly operated—electric power could be used for pumping, thus conserving the higher grade fuel materials, oil and gas, now so commonly used in pipe line pumping stations.

The other oil line rights of way are also of great interest as they suggest possible advantageous northern routes for Giant Power lines.

The map (Figure 4) of Natural Gas Transmission Pipe lines in Pennsylvania is reduced from a large scale map, a copy of which will be sent to the Legislature with the report of the Giant Power Survey.

There will also be included in the files an analysis of the production and purchase of the natural gas supply of the State and its distribution to several classes of consumers.

This great net work of millions of dollars' worth of gas pipe lines is becoming hungrier every year for additional sources of supply of fuel gas. It will be noted that some of these mains lie close to any probable location of Giant Power Electric Stations and coal treating plants so that only short connecting pipe lines would have to be built to feed the coal gas therein

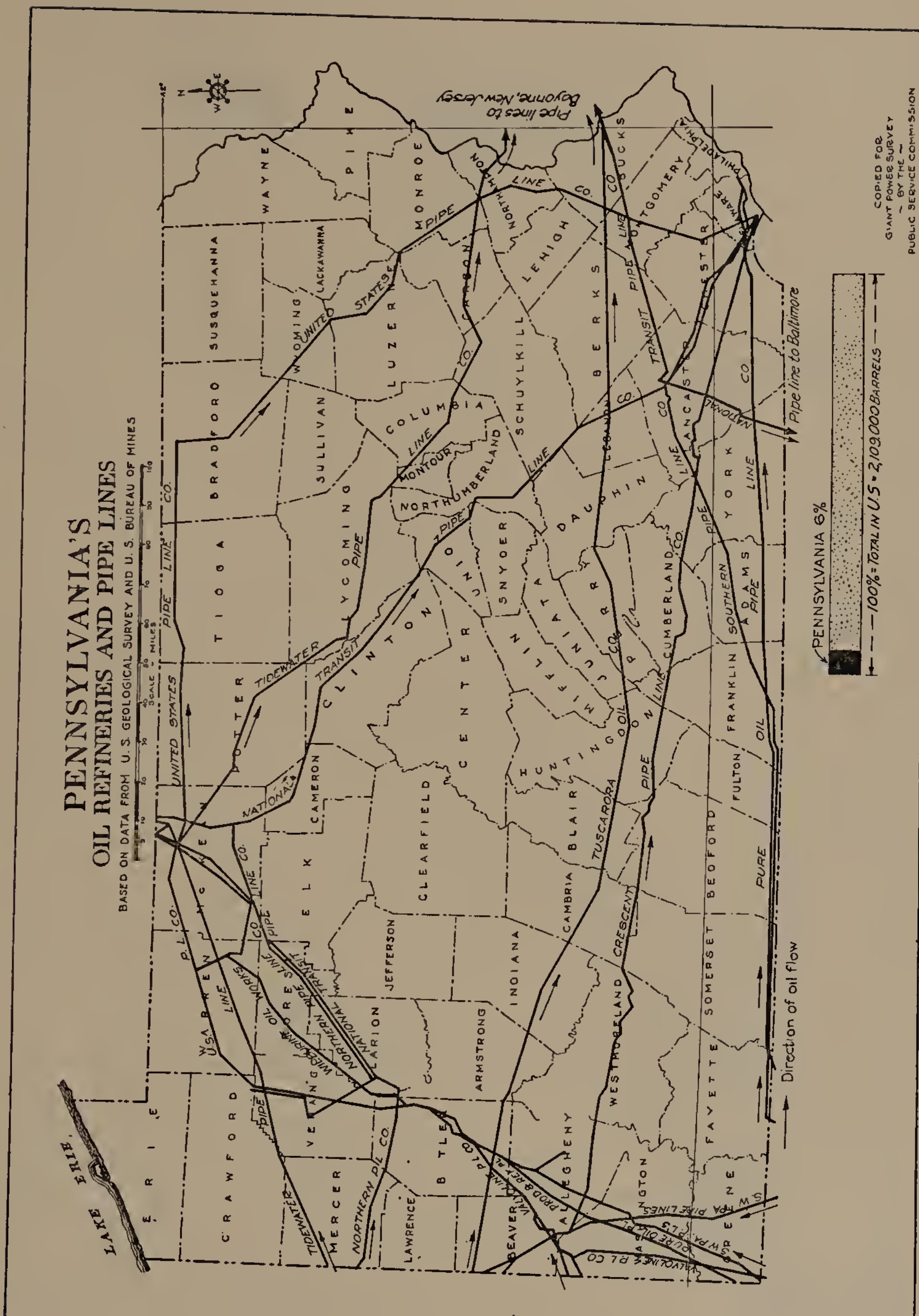

FIG. 3. OIL PIPE LINE ROUTES ACROSS PENNSYLVANIA

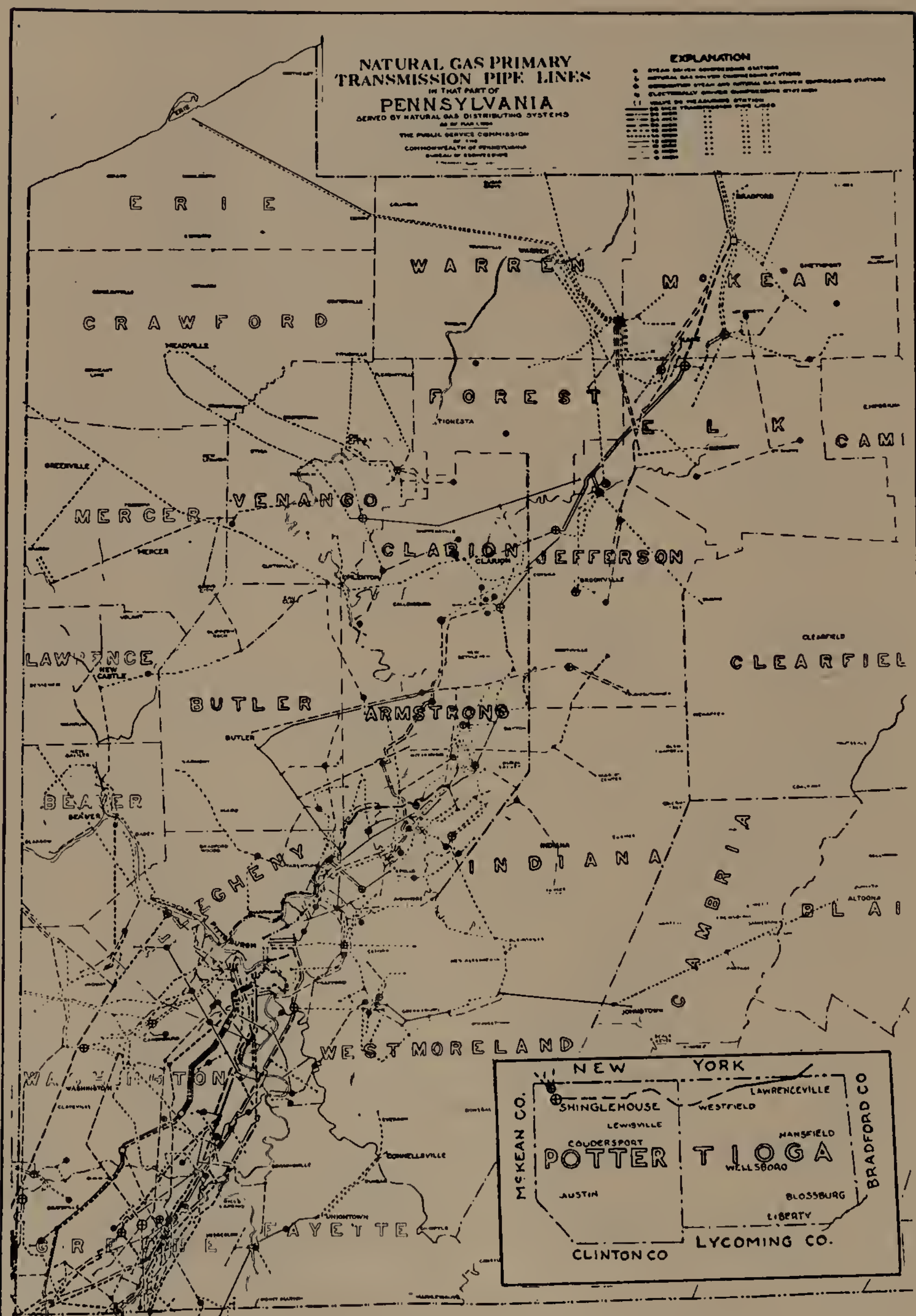

FIG. 4. EXISTING NATURAL GAS PIPE LINES (1924)

produced into the existing natural gas main system. Already, a pipe line extends as far east as Altoona (where it serves 12,000 consumers,) nearly one-third of the way to Philadelphia. If the supply of natural gas could be considered as adequate and permanent, doubtless we should see pipe lines pushed still farther east. When the many millions of tons of coal annually shipped from the mines of Western Pennsylvania are pretreated with the recovery of by-products, a permanent and large supply of gas will be made available. Combined with the joint use of rights of way and joint operation, the costs of producing and delivering gas should be so reduced as to make feasible delivery to the eastern cities.

Assuming a transmission distance of 300 miles from Western Pennsylvania to the city limits of Philadelphia, (which is about 40 miles longer than the straight line distance); delivery pressure of 250 lbs. per sq. in. at the discharge valves of the compressors; a pressure of 5 lbs. per sq. in. at point of final delivery; and with compressors located every fifty miles:

A 16″ pipe line would deliver 39 million cu. ft. each 24 hears or 14 billion cu. ft. per year.

A 20″ pipe line would deliver 70 million cu. ft. each 24 hours or 25 billion cu. ft. per year.

Since the total volume of manufactured gas distributed in the district within 50 miles of Philadelphia does not yet quite reach 25 billion cu. ft. per year, it is evidently physically practicable to transmit the great bulk of the gas requirements of the Philadelphia district by pipe line from the Western Pennsylvania coal mining districts.

To be economically feasible, the transmitted gas would form the base supply. Peak demands in the cities supplied would have to be met from ample local storage or from locally operated gas works of a type suitable for intermittent operation, such as the carburetted water gas process.

The present freight rate on coal from the important coal fields to Philadelphia is $2.68 per short ton. With a yield of 11,500 cu. ft. of gas and 1100 lbs. of coke available for sale per short ton of coal charged, the net freight charge per 1000 cu. ft. of gas is $.105.

In a pamphlet entitled "A Fuel Program for the City of Buffalo, N. Y." issued in 1924, an estimate is given of the capital charges and operating costs of moving gas 125 miles from the mine region of Pennsylvania to Buffalo, which amounts to $.0469 per M cu. ft. The maximum capacity of the equipment was taken at 24 million cu. ft. per 24 hours, but the total volume assumed as transmitted in a year was only 61% of the pipe line capacity or about 5 1/3 billion cu. ft. No allowance was made in these estimates for pipe-line leakage and condensation losses.

The cost of installation and operation increase directly with the distance; but in considering the Philadelphia situation, we should need to move about 4 times as much gas tending to reduce both investment and operating costs per 1,000 cu. ft. of gas moved, and if operated as part of a Giant Power system as outlined above further economies would appear which should tend to keep the transmission costs inside the cost of freight on coal to Philadelphia.

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density of population—Formation of farmer's organizations and details of equipment best suited to farmer's needs. Photographs and charts.

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Great economies due from Giant Power, the realization of which is a fundamental part of the program of the country's engineers. (Note also "Dreams That Are Facts." North American Editorial, June 5, 1924.)

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Evolution of Giant Power Survey and its seven proposals. Map of transmission lines in the State.

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HENRY FORD TACKLES A NEW JOB—Colliers, October 18, 1924.

Mr. Ford's bid for Muscle Shoals definitely withdrawn. He is making plans for generation of electricity from coal mines in Kentucky cheaper than it can be done at Muscle Shoals.

ARE GANDHI AND FORD ON THE SAME ROAD—Drew Pearson, Asia, December, 1924.

Mr. Ford and Gandhi are both concerned with moving industry to the farm which not only increases the efficiency of the workman but helps to reduce the "economic ills" growing out of overcrowded cities.

A HUNDRED YEARS FROM NOW—Charles P. Steinmetz, American Legion Weekly, August 17, 1923.

THE LONG LOOK AHEAD—Morris L. Cooke, Survey Graphic, March, 1924.

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PANDORA'S BOX—Robert W. Bruere, Survey Graphic, March, 1924.

MAJOR POWER PROBLEMS—John Hays Smith, Address before International Association of Municipal Electricians, Reading, Pa., September 26, 1923. (Pub. in 28th Annual Report International Association of Municipal Electricians.)

POWER AND ROADS ARE RELATED—Clip Sheet, National Highways Association, November 29, 1923.

Intimate relation of the Giant Power system of Pennsylvania and the northeast Superpower system with highway development.

PUBLIC UTILITY RATES—For 542 Kansas Cities. League of Kansas Municipalities, Lawrence, Kansts, 1923.

Rates and data for 237 municipally owned plants and 179 privately owned plants.

SHIPS, OIL AND THE TEN COMMANDMENTS—Gifford Pinchot, Saturday Evening Post, May 17, 1924.

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Review of the Giant Power number of the Survey Graphic giving

something of the "vast magnitude of the task reconciling the manifold interests of the various states and localities in the national power project."

Vongrosser Arbeit—Kraftwerk und Strausse, Verlag A. Franke, Bern, 1921.

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Appendix E

QUANTITATIVE ENGINEERING FIELD RECONNAISSANCES

Covering Electric and Telephone Service for Typical Rural Districts as made by Representative Service Companies

INTRODUCTION

By Morris L. Cooke

For such bearing as they may have on a further study of rural electrification it seemed desirable to include in this report quantitative data as to equipment, etc., held to be required in providing electrical service both alone and when combined with telephone service, to given districts chosen more or less at random but believed to be fairly typical.

Having been advised of the willingness of the service companies to provide these data and in order to make possible some uniformity in the returns the following letter of request and instruction was sent to the co-operating companies:

> "This Survey considers it desirable from a social point of view to reach at least some very broad conclusions as to what is involved in the way of construction in reaching various percentages of the 200,000 odd farms in Pennsylvania with electric service. Obviously the higher the percentage the greater the cost. To reach every farm is obviously impossible economically and probably always will be. But there is doubtless a critical point somewhere between the present situation and 100 per cent. of rural electrification which can be readily discovered and beyond which it will be idle to even speculate.
>
> "To put ourselves in a position to picture this situation adequately to the Legislature and the people we have scheduled the road mileage by townships, counted both population and farms, eliminated the small unincorporated towns, plotted forest and waste areas and otherwise reached broad conclusions as to what there is to electrify in the 2000 odd townships of the State.
>
> "From various sources, from the opinions of qualified individuals, from technical papers, through studying actual installations in this country and Canada, and otherwise we have obtained considerable data as to the cost of rural line work if undertaken on a large scale. We are promised through the good offices of the Pennsylvania Electric Association further cost data based on actual Pennsylvania experience.
>
> "We feel that it would be very helpful in our further thinking and planning if we could secure from your company what for the lack of a better name, we will call a 'quantitative engineering field reconnaissance,' as contrasted with a more detailed survey of a township or a section of such township not more than 25 square miles in area. We must stress

the fact that you would not be warranted in making your measurements too exact or in taking too much time in reaching conclusions on debated engineering questions. We are, however, anxious to see 'spotted' on a purchased map of the territory we have selected, the individual farms and the transmission and distribution lines required to reach them, drawn in. Then we want a statement in broad terms as to the character of the farms and business which might be expected all as requested on inquiry sheet herewith. Of course, where the proposed lines intersect towns enroute we would like a picture of the extent and business possibilities of the town. A section taken from any part of .... County will answer our purposes.

"We are asking in these typical territories for an extent of electrification obviously beyond present possibilities. Where there are one or more single farms so situated as to be 'sports' exclude them. Also if there appears from your observation of the territory to be a considerable section which is distinctly less attractive from a business standpoint than the balance we would like to have this indicated on the map. Thus you might isolate 50% plus of the territory which would stand out above the balance as a development proposition.

"The statement which we are principally desirous of securing from you is quantitative. But in order to meet suggestions we have provided a section where cost estimates can be made if you desire to include them.

"We realize that this letter gives a large order and by no means answers all of the questions that may come up. But as we want to secure your idea of what such a reconnaissance should be, this may not be without its virtue. If for any reason you do not feel that you are situated so as to undertake this inquiry at this time, please frankly say so."

INQUIRY SHEET

ENGINEERING DATA

- Business Survey
  - No. of Prospects (See Sub-Appendix A) ......
    - (a) Prosperous farmers sure to take current.
    - (b) Average prospect.
    - (c) Least dependable prospect.
  - Probable consumption of energy ....
    - Class "a" prospects.
    - Class "b" prospects.
    - Class "c" prospects.
- Map of Proposed Lines
- Physical Constants of Proposed Lines .....
  - Proposed Voltage of Primary Lines. (Indicate point at which primary lines are fed).
  - Length of proposed Pole lines.
  - Length of Primary lines.
  - Number of Primary Wires and Size.
  - No., Sizes and Locations of Transformers. (Indicate on Map).
  - Size and kind of poles.
  - Spacing of poles.
  - Location and Spacing of Primary Wires on Poles.
  - Anticipated Maximum Demand.
  - Anticipated Load Factor.
  - Anticipated Power Factor.
- Bill of materials fully itemized, quantities only.
- Estimated Labor, hours only.
- Estimated Cost of Extensions (Rural Lines)
  - Cost of Engineering Reconnaissances.
  - Cost of Engineering.
  - Cost of securing Right-of-way.
  - Cost of Right-of-way.
  - Overheads during construction.
  - Cost of Freight and Haulage.
  - Cost of Materials including transformers. (Itemized).
  - Cost of Labor.
- Cost of Service (from Rural line to customer's premises) ....
  - Average Length of Service from transformer to main switch on consumer's premises.
  - Average size and spacing of wires.
  - Bill of materials, quantities only.
  - Labor, hours only.
  - Average Size and cost of meter installed.
  - Cost of Average Service Complete from Secondary of transformer to main switch in consumer's premises.

SUB-APPENDIX A

It has been suggested to us to describe in a very general way our present thought as to how such prospects might be divided. Without imposing any hard and fast rule we propose for your consideration, segregating possible customers as per their prospective equipments somewhat as follows:

(a) Prosperous farmers sure to take current.

HOUSE

Place of use	*No. and size of lamps*	*Total Watts*
Living Room:		
Reading Lamp	2- 40 watt	80
Ceiling or wall fixture	3- 40 watt	120
Dining Room, ceiling fixtures	2- 40 watt	80

Place of use	*No. and size of lamps*	*Total watts*
Kitchen	2- 40 watt	80
Pantry	1- 40 watt	40
Bedroom	2- 25 watt	50
Bedroom	2- 25 watt	50
Bedroom	2- 25 watt	50
Bathroom	1- 40 watt	40
Porch	1- 40 watt	40
Hall, downstairs	1- 40 watt	40
Hall, upstairs	1- 25 watt	25
	Total for House	695

OUTBUILDINGS

Barn, horse	4- 40 watt	160
Barn, cow	4- 40 watt	160
Barn, hay	2- 40 watt	80
Pig house	1- 40 watt	40
Chicken house	4- 40 watt	160
Watering trough	1- 60 watt	60
Barn-yard entrance	1-100 watt	100
Front gate	1-100 watt	100
	Total for Outbuildings	860
	TOTAL FOR FARMSTEAD	1,555

ELECTRICAL APPLIANCES

	Watts or h. p.	*Percent of (a) Farms having Appliances*
Flatiron	525 watts	80
Electric Fan	40 watts	10
Cream Separator	½ h. p.	25
Washing Machine	¼ h. p.	35
Electric Range	7,000 watts	25
Vacuum Cleaner	100 watts	25
Electric Heaters	600 watts	25
Water Pumps	½ h. p.	25
Toaster	600 watts	30
Sewing Machine	⅛ h. p.	30

(b) Average Prospect.

HOUSE

Place of Use	*No. and Size of Lamps.*	*Total Watts*
Living room	2- 40 watt	80
Dining room	2- 40 watt	80

Kitchen	2- 40 watt	80
Bedroom	2- 25 watt	50
Bedroom	2- 25 watt	50
Bedroom	1- 25 watt	25
Porch	1- 25 watt	25
	Total for House	390

OUTBUILDINGS

Barn, horse	2- 40 watt	80
Barn, cow	4- 40 watt	160
Chicken house	4- 40 watt	160
Barnyard	1-100 watt	100
	Total for Outbuildings	500
	TOTAL FOR FARMSTEAD	890

ELECTRICAL APPLIANCES

	No. of watts	*Percent of (b) Farms having the Appliances*
Flatiron	525 watts	50
Cream separator	¼ h. p.	15
Washing machine	¼ h. p.	25
Electric range	7,000 watts	10
Vacuum Cleaner	100 watts	20
Electric heaters	600 watts	15
Water pumps	½ h. p.	20
Toaster	600 watts	20
Sewing machine	½ h. p.	20

(c) Least dependable prospect.

HOUSE

Place of Use	*No. and Size of Lamps.*	*Total Watts*
Living room	2-40 watt	80
Kitchen	1-40 watt	40
Bedroom	1-25 watt	25
Bedroom	1-25 watt	25
	Total for House	170

OUTBUILDINGS

Barn, horse	2-25 watt	50
Barn, cow	2-40 watt	80
	Total for Outbuildings	130
	TOTAL FOR FARMSTEAD	300

ELECTRICAL APPLIANCES

	H. P. or Watts	*% of (c) Farms having appliances*
Flatiron	525 watts	30
Cream Separator	½ h. p.	3
Washing Machine	¼ h. p.	15
Vacuum Cleaner	100 watts	10
Water Pumps	½ h. p.	10
Toaster	600 watts	5
Sewing Machine	⅛ h. p.	5

Our purpose would have been accomplished if these studies had been confined to quantities. But as we were requested to do so, we made it possible for price estimates to be included. All but one of the electrical service companies have so included cost estimates in more or less detail. These cost estimates have added materially to the general value of the reports. These estimates are based on the experience of each company in its own operating territory and are affected by prices of labor and material, type of construction, voltage of lines, character of the country through which the proposed lines would run thus affecting construction costs, right of way expense and cost of securing State Highway permits, etc. We are publishing these figures exactly as they were submitted to us. They must be used, therefore, with the understanding that they represent only the best judgment of the company submitting them. But as in most cases, final figures include estimated overheads, contingencies and intangibles, and as each of the companies arrive at their conclusions by somewhat different methods, and in fact, reach quite different results, some review of these price figures would be required before attaching to them any degree of finality.

That there is considerable variance as between the returns from the several companies was to be expected. The experience of the different companies with regard to rural electrification has varied widely. Because it was believed to be helpful to have such points of difference developed, the several companies were asked to work up their returns without conference with their associates. The following table makes a comparison as between some of the key figures. The reader is cautioned against reading too much significance into either likenesses or differences of comparative figures. We are seeking a way to affect rural electrification. Anything that throws light on the present situation may prove helpful.

In compliance with the foregoing the companies listed below have furnished studies most of which have been reproduced in the following pages. The Summary Sheet however carries a number of figures which do not exactly correspond with those in the estimates due to a number of minor corrections and changes which later deliberation caused their originators to introduce. These alterations are for the most part quite immaterial and were not made in the body of the estimates through lack of time before going to press.

Company	Exhibit No.	Letter of Designation
Pennsylvania Power and Light Co.		
Liberty Township, Montour County	1	A
Philadelphia Suburban Gas & Electric Co.		
Northampton Township, Bucks County	2	B
Keystone Power Corporation		
Patton Township, Center County	3	C
Erie Lighting Company		
LeBoeuf Township, Erie County	4	D
Duquesne Light Company		
Pine Township, Allegheny County	5	E
Penn Central Light and Power Company		
Menno and Union Townships, Mifflin County	6	G
Metropolitan Edison Company		
Tilden Township, Berks County	7	F
Bell Telephone Company		
Menallen Township, Adams County		
Tilden Township, Berks County		
New Britain Township, Bucks County	8	

SUMMARY OF SURVEYS OF SUPPOSEDLY TYPICAL PENNSYLVANIA TOWNSHIPS IN CONNECTION WITH A STUDY OF RURAL ELECTRIC SERVICE

As Revised to include Corrections of the Interested Electric Companies.

Company	Primary Line		Cost			Pole Length and Spacing feet	Customers								Simultaneous Max. Demand of Group Kw.	Load Factor %	Power Factor %	Service		
							Class A		Class B		Class C		Total							
	Voltage	No. Miles	Total Cost including overhead; excluding service, meter and transformer	Per Mile of Primary Line	Per Cust.		No.	Kwh. per cust. per month	No.	Kwh. per cust. per month	No.	Kwh. per cust. per month	No.	Kwh. per cust. per month				Average Length—Feet	Service and Meter installed including Overhead	Cost transformers per cust. installed including Overhead
A	6,900	45	$109,100	$2,430	$581	150′	1	85	20	29	167	21	188	22	35	16	85	100	$23.60	$57.20
	11,000	....	....	......	....	35′B														
B	2,300	43.3	77,020	1,780	384	30′	18	58	183	23	...	..	201	26	60	14	70	80	24.50	54.50
						175′														
C—Stand. spec.	6,900	30.3	57,716	1,900	705	35′	1	40	45	30	36	20	82	26	20	14.5	40	490	66.20	54.40
						150′														
C—Minimum spec.	......	30.3	40,942	1,350	499	35′	1	40	45	30	36	20	82	26	20	14.5	40	490	66.20	54.40
						200′														
D—1st year	2,300	34.4	....	......	232	30′	70	Mill	villa	ge	...	..	...	....	...	......	..	...	......	......
						250′	36	68	68	25	94	17	198	29	108	15–20	75	300	44.04	23.99
D—2d year	......	34.4	45,982	1,336	172	250′	...	...	...	..	...	..	268	35	152	15–20	75	300	32.50	17.72
E	......	28.4	55,500	1,960	295	35′	22	100	160	31	6	15	188	38	90	5	..	...	123.00	30.75
						200′														
F	2,300	36.7	....	......	....	30′	...	...	88	20	49	12	137	17	30	10	85	...	......	......
						135′														
G	2,300	39.5	51,437	1,302	297	30′	...	...	106	20*	67	9*	173	15.7	67	4.75	85	100	18.00	16.45
						150′														

* Believed too small to be typical.

EXHIBIT NO. 1

LIBERTY TOWNSHIP, MONTOUR COUNTY

BY PENNSYLVANIA POWER AND LIGHT COMPANY

1. *Business Survey* *Class of Customer*	*Number*	*Annual Kwh. per Customer*	*Consumption Total Kwh.*
A	1	1,000	1,000
B	20	350	7,000
C	167	250	41,750
All	188		49,750

2. Proposed voltage of primary lines. 11,000 volts, 3 phase, 4 wire, 60 cycle.

3. Length of proposed pole lines. 45 miles.

4. Length of primary lines. 4 wire, 3 phase, 8.35 miles; 3 wire, 3 phase, .57 miles; 2 wire, single phase, 30.7 miles.

5. Number of primary wires and size. The previous question (4) will give information relative to number of wires. The size of wires selected are main line No. 2 and No. 4 neutral, branch lines No. 4 and No. 6 neutral, single phase lines No. 6.

6. Number, sizes and location of transformers. Indicated on map.

7. Size and kind of poles. Where there is no tree interference or other objects to clear, 35 feet, Class "B" Chestnut poles have been selected. Tree conditions and other obstructions will require the use of taller poles in certain cases.

8. Spacing of poles. 150 feet, normal spacing.

9. Location and spacing of primary wires on poles. Primary wires to be located on 8 ft. crossarms at top of pole, the spacing between conductors being 29 inches except between pole pins where it will be 30 inches.

10. Anticipated maximum demand. 35 Kw.

11. Anticipated yearly load factor. 16% on consumption.

12. Anticipated power factor. 85% at peak load.

13. Bill of materials, exclusive of services and meters. See pages 420 and 421.

14. Estimated labor, hours only, exclusive of services and meters, 52,500 man hrs.

15. Cost of engineering and engineering reconnaissance. $5080.

16. Cost of securing right of way and cost of right of way. $4400.

17. Overheads and contingencies. $13,220.

18. Cost of handling and hauling. $3600.

19. Cost of materials including poles, primary and secondary conductors, also transformers. $62,750.

20. Cost of labor. $31,460.

21. Average length of service from secondary mains to point of connection to consumers' premises. 100 ft.

22. Average size and spacing of service wires. No. 8—8″ spacing.

23. Bill of material for services. See page 421.

24. Labor for services including cost of meter installation. 600 man hrs.

25. Average cost and size of meters installed. 5 amp., 110 volt, 2 wire, cost $11.

26. Cost of average service complete from secondary mains to point of connection to consumers' premises, excluding cost of meters and overheads. $9.10.

Estimated proportional cost of power house, transmission lines, substation, etc.,	$7,123
Estimated cost special investment	124,290
Estimated total cost of facilities to render service	$131,413
Estimated revenue	4,975
Estimated operating expense	$8,472
Loss from operation	$3,497

BILL OF MATERIAL—PRIMARY AND SECONDARY EXTENSIONS

1	50 ft. Class "B" Chestnut Poles	27
2	45 ft. Class "B" Chestnut Poles	60
3	40 ft. Class "B" Chestnut Poles	300
4	35 ft. Class "B" Chestnut Poles	1,200
5	30 ft. Class "B" Chestnut Poles	130
6	3¾" × 4¾" × 8'-0" L. L. Y. P. Crossarms	2,100
7	¼" × 1¼" × 28" Crossarm Braces	4,200
8	⅜" × 4½" Carriage Bolts	4,200
9	⅝" × 14" Machine Bolts	2,585
10	⅝" × 18" Machine Bolts	340
11	2¼" × 2¼" × $\frac{3}{16}$" Square Washers	8,850
12	⅝" × 18" D. A. Bolts	650
13	½" × 4" Lag Screws	2,925
14	Locust Pins 1" Top ½" Shank 9" Long	8,400
15	11 KV Brown Porc. Pin Insulators	4,400
16	4 KV Brown Porc. Pin Insulators	2,025
17	10" Disc Porc. Strain Insulators	300
18	Forged Insulators Hooks	300
19	Thimble Clevis Dead End	300
20	Bolt Clevis	400
21	6½" Wet Process Porc. Strain Insulators	870
22	Insulator Clevis	100
23	½" Guy Thimbles	720
24	Three Bolt Guy Clamps	2,710
25	Guy Hooks	770
26	Guy Shims	770
27	Anchor Rods	385
28	Anchor Plates	385

29	⅜″ 7 Strand Siemans Martin Galv. Guy Wire	17,225 ft.
30	#2—3 Strand S. D. Bare Copper Wire	17,500 lbs.
31	#4—M. H. D. Solid Bare Copper Wire	10,000 lbs.
32	#6—M. H. D. Solid Bare Copper Wire	14,500 lbs.
33	#4—M. H. D. T. B. W. P. Solid Copper Wire	7,875 lbs.
34	#6—M. H. D. T. B. W. P. Solid Copper Wire	22,400 lbs.
35	5 KVA 6900/115/230 Volt Transformers	1
36	3 KVA 6900/115/230 Volt Transformers	6
37	1½ KVA 6900/115/230 Volt Transformers	73
38	11 KV Lightning Arresters (Grounded Neutral)	20
39	¾″ Galv. Ground Pipe	800 ft.
40	¾″ Ground Caps	80
41	¾″ Ground Points	80
42	Wood Moulding for Ground Wire	2,000 ft.
43	11 KV Fused Cutouts	80
44	Secondary Racks	825

Bill of Material—Services

1	#8 S. D. T. B. W. P. Solid Copper	3,750 lbs.
2	Two Point House Brackets	200
3	Three Point House Brackets	25
4	5 Amp. 110 Volt, 2 Wire Meters	167
5	10 Amp. 110 Volt, 2 Wire Meters	20
6	25 Amp. 110 Volt, 2 Wire Meters	1
7	$\frac{5}{16}$″ × 2½″ Gimlet Point Lag Screws	450

Summary of Costs

Poles, Towers and Fixtures	$58,910.00
Overhead Conductors	27,730.00
Sectionalizing Switches	2,000.00
Transformers	9,170.00
Services	1,650.00
Meters	2,130.00
Total Specific Construction	$101,590.00
Right of Way	4,400.00
	$105,990.00
General and Legal Expenses and Construction Camp ..	5,000.00
Engineering Surveys	5,080.00
Contingencies	5,000.00
Interest during Construction	3,220.00
Total	$124,290.00

LIBERTY TOWNSHIP, MONTOUR COUNTY

EXHIBIT NO. 2

NORTHAMPTON TOWNSHIP, BUCKS COUNTY

BY PHILADELPHIA SUBURBAN GAS AND ELECTRIC COMPANY

The territory selected for an Electric Light and Power Survey of a rural district typical of that in which the Philadelphia Suburban Gas and Electric Company operates, covers approximately twenty-five (25) square miles in Northampton Township and includes about four-fifths (4/5) of the total area of this township. The Philadelphia Suburban Gas and Electric Company now has some lines in this territory which serve the towns of Holland, Richboro and Churchville. The present lines are operating at 2300, 220 and 110 volts and the consumers served by them are nearly all located in the several small towns. Practically no farms are served by these lines.

Two sets of data have been prepared; one considering the additional business which might be obtained over and above that now served, and the other considering the entire territory both towns and farms. In the latter it has been assumed that no lines now exist and data is based on building new lines throughout under present day conditions.

The farms in this territory are similar to the average farm found in Bucks County. Being close to Philadelphia there are some truck farms raising produce which is hauled daily to the city by truck. But the majority of the farms raise large crops such as corn, wheat and hay. Several of them have large dairies. Many of the farms are owned by prosperous individuals who use them as summer homes. Several of the larger farms are situated at quite some distance from our present lines and have already installed their own electric plants.

The towns of Holland, Richboro and Churchville are purely agricultural. The inhabitants are nearly all farmers and retired farmers. There is no possibility of any development which would lead to the consumption of power in arge quantities, due to geographical location and lack of transportation facilities.

RECONNAISSANCE CONSIDERING ONLY ADDITIONAL PROSPECTIVE BUSINESS OVER AND ABOVE THAT NOW SERVED

1. Territorial possibilities:
   (a) Number of buildings surveyed 188
   (b) Number of good prospects—Power and Light .. 10
   (c) Number of average prospects—Light only 107
   (d) Number of non prospects 61
   (e) Number of prospects not served—"Sports" 10
2. Probable consumption energy:
   (a) By each power and light consumer .... 700 Kwh. per yr.
   (b) By each lighting consumer .... 275 Kwh. per yr.
3. The demand for the territory not considering the above towns would be 40 kilowatts.
4. The anticipated average power factor would be 65.
5. The yearly load factor under this consideration is estimated at 15%.
6. No data.
7. Construction:
   (a) Length of proposed lines necessary to obtain additional business:

	Public Highway	*Private Property*
Single Phase	5.60	1.30
Three Phase	23.11	2.64
Secondary	2.69	3.62

Total length of proposed lines not including secondaries on same poles as primaries = 35.39 miles. Total length of primary lines (single and three phase) = 32.65 miles.

(b) Specification and basis of estimates.

(1) All primaries and secondaries to be #4 M. H. D. bare copper

wire. Primaries to be single phase, two wire and three phase, three wire. Secondaries to be not greater than 1200 ft. in length.

(2) All poles to be Class "B" N. E. L. A. specification Western Red Cedar with ½" Pentrex butt treatment. Minimum size of poles to be 30′ for supporting wood, and 25′ for guy stubs.

(3) Spans to be 175 ft. in length. This gives approximately 30 poles per mile. The calculations are based on an average of thirty-five (35) poles per mile. This allowance is made to cover an added cost of higher poles and additional poles used as guy stubs and poles used in short spans due to angles.

(4) Primary lines to be run on N. E. L. A. standard 4 and 6 pin arms. Minimum distance between wires to be fifteen inches (15 in.) for primaries and eight (8) inches for secondaries. All secondaries to be run on Pierce #1258 and #1358 secondary racks.

(5) Line would be supplied from our substations at Newton and Hatboro.

8. Bill of materials (quantities only) for constructing lines to serve additional consumers.

Poles	1,100
Crossarms	1,415
Crossarm braces	2,826
Double arm bolts	628
Machine bolts	1,400
Secondary racks—3 wire	100
Secondary racks—5 wire	50
Toe bolts	2,669
Carriage bolts	2,826
Round washers	2,826
Square washers	5,636
Locust pins	5,652
Guy clamps	942
Guy wire (ft.)	29,500
Guy insulators	942
Anchor rods	314
Guy hooks	1,256
Strain plates	1,964
Wire—#4 bare solid copper (lbs.)	65,400
Insulators—#44 Locke	3,700
Spool insulators	400
Transformers—1½ K. V. A.	13
2300 Volts to 3 K. V. A.	13
110/220 Volts to 5 K. V. A.	52
110/220 Volts to 7½ K. V. A.	10
110/220 Volts to 10 K. V. A.	12
Material for transf. racks	
Crossarms—6 pin	102

Crossarms—4 pin	96
Crossarm braces	396
Double arm bolts	132
Machine bolts	132
Toe bolts	198
Brace bolts	396
Round washers	396
Square washers	792
Locust pins	996
Fletcher pins	532
Wire—#4 copper	396
Insulators—#44 Locke	532
Ground rods complete	68
Lightning arresters	166

9. Estimated labor (hours only):

(a) To dig pole holes	4,150
(b) To gain and shave	2,595
(c) To haul poles	2,075
(d) To set poles	2,960
(e) To dig anchor holes	1,480
(f) To erect crossarms	1,445
(g) To erect racks	185
(h) To string wire	10,800
(i) To put on guys	1,220
(j) To erect transformers	1,440
Total Hours	28,310

10 Costs:

(a) Cost of material itemized:

Poles	$14,685.00
Crossarms	1,285.83
Crossarm braces	339.12
D. A. Bolts	106.72
Machine bolts	98.00
Secondary racks—3 W.	118.00
Secondary racks—2 W.	43.00
Toe bolts	106.76
Brace bolts	56.52
Round washers	14.13
Square washers	112.72
Locust pins	169.56
Three bolt clamps	207.24
Guy wire—⅜″ steel	1,180.00
Guy insulators	141.30
Anchor rods	135.09
Guy hooks	100.48

Strain plates	178.56	
Wire—#4 bare	9,810.00	
Insulators—Locke #44 White	592.00	
#355 insulators	40.00	
		$29,520.03
(b) Transformer rack materials:		
Crossarms—6 pin	$116.28	
Crossarms—4 pin	87.36	
Crossarm braces	46.53	
D. A. bolts	22.44	
Machine bolts	9.24	
Toe bolts	5.94	
Brace bolts	7.92	
Round washers	1.98	
Square washers	15.84	
Locust pins	29.88	
Fletcher pins	69.16	
Ground rods	169.32	
Lightning arresters	888.10	
Wire—#4 M. H. D. copper	59.40	
Insulators—#44 Locke	85.12	
		$1,614.51
Total all materials		$31,134.54
Total freight haulage, storeroom expense (10% of total for material)		3,113.45
Total all materials, including freight, haulage, etc.		$34,247.99
(c) Transformers 2300—220/110 volts		
1½ KVA	$440.05	
3 KVA	631.41	
5 KVA	3,412.76	
2½ KVA	856.70	
10 KVA	1,248.32	
		$6,598.42
Freight, haulage and Storeroom expense (5% of total)		329.92
Total for transformers		$6,928.34
Total cost of all materials, including transformers, freight, etc.		$41,176.33
(d) Cost of labor:		
To dig holes	$4,400.00	

To gain and shave poles	2,750.00	
To haul poles	2,200.00	
To set poles	3,140.00	
To dig anchor holes	1,570.00	
To erect crossarms	1,530.00	
To erect racks	196.00	
To erect transformers	1,480.00	
To put on guys	1,295.00	
To string wire	10,800.00	
Total labor		$29,361.00

11. Summary of Costs:

(a) Cost of right of way:	
(1) No lines to be built on private property except those to serve the owner of the property	
(2) Pole permits—State Highway	$286.20
(3) Trimming and clearing	1,800.00
Total right of way	$2,086.20
(b) Total cost of all materials, including transformers, freight, etc.	$41,176.33
(c) Total cost of labor	29,361.00
Total	$72,623.53
(d) Cost of engineering (3%) of total of all material, labor and right of way	2,178.71
(e) Overheads during construction (2%) of total for all material, labor and right of way	1,452.57
(f) Cost of engineering reconnaissance	150.00
Total	$76,404.81
(g) Cost of services, including meters:	
(1) 2 W. service (75 services @ $20.96)	1,572.00
(2) 4 W. service (42 services @ $61.79)	2,595.18
TOTAL COST TO SERVE BUSINESS UNDER THIS CONSIDERATION	$80,571.99

SURVEY DATA

CONSIDERING THE ENTIRE TERRITORY TO BE SERVED—EXISTING LINES TO BE BUILT WHERE THEY NOW ARE, AT PRESENT DAY PRICES

1. Territorial possibilities:

(a) Number of buildings surveyed 313

(b) Number of good prospects—Power and Light 18
(c) Number of average prospects—Light only 183
(d) Number of non prospects 61
(e) Number of prospects not served—"Sports" 10

2. Probable consumption of energy:
(a) By each power and light consumer .... 700 kwh. per yr.
(b) By each light consumer .... 275 Kwh. per yr.

3. The maximum demand anticipated under this condition was found in the same manner as in the previous case. The maximum anticipated demand is 60 kilowatts.

4. An increase in lighting load in the towns would tend to increase the average power factor to 70.

5. The yearly load factor under these conditions became 14%.

7. Construction:
(a) Length of proposed lines necessary to serve entire territory:

	Public Highway	*Private Property*
Single phase	9.93	1.72
Three phase	25.81	2.64
Secondary	3.19	....

Total length of proposed lines not including secondaries on same poles as primaries = 43.29 miles. Total length of primary lines (single and three phase) = 40.1 miles.

(b) Specification and basis of estimates.

(1) All primaries and secondaries to be #4 MHD bare copper wire. Primaries to be single phase, two wire and three phase, three wire. Secondaries to be not greater than 1200 ft. in length.

(2) All poles to be Class "B" N. E. L. A. specification Western Red Cedar with ½″ Pentrex butt treatment. Minimum size of poles to be 30′ for supporting wood, and 25′ for guy stubs.

(3) Spans to be 175 ft. in length. This gives approximately 30 poles per mile. The calculations are based on an average of thirty-five (35) poles per mile. This allowance is to cover the added cost of higher poles, and the additional cost of poles used as guy stubs and in short spans due to angles.

(4) Primaries to be run on N. E. L. A. standard 4 and 6 pin cross-arms. Minimum distance between wires to be fifteen (15) inches for primaries and eight (8) inches for secondaries. All secondaries to be run on Pierce #1258 and #1358 secondary racks.

(5) Lines would be supplied from our sub-stations at Hatboro and Newtown.

8. Bill of materials (quantity only) for constructing lines to serve entire territory.

Poles—Class "B" N. E. L. A. Std. Western Red Cedar	1,260
Crossarms—N. E. L. A. Std. 4 and 6 pin	1,620
Crossarm braces	3,240
Double arm bolts	720
Machine bolts—⅝″ dia.	1,400
Secondary racks—5 wire	110

Secondary racks—3 wire	55
Toe bolts	2,700
Carriage bolts	3,240
Round washers	3,240
Square washers	5,630
Locust pins	6,480
Three bolt clamps	1,080
Guy wire—3/8" D. G. S. S. (Ft.)	34,000
Guy insulators	1,080
Anchor rods	360
Guy hooks	1,440
Strain plates	2,160
Wire—#4 MHD bare solid copper (lbs.)	77,470
Insulators—Locke #44 white	4,200
Insulators—#355 Pierce	450
Transformers—1½ KVA.	14
Transformers—3 KVA.	24
Transformers—5 KVA.	54
Transformers—7½ KVA.	13
Transformers—10 KVA.	12
Material for transf. racks:	
Crossarms—6 pin	102
Crossarms—4 pin	153
Crossarm braces	510
Double arm bolts	170
Machine bolts	170
Toe bolts	255
Brace bolts	510
Round washers	510
Square washers	1,020
Locust pins	1,416
Fletcher pins	646
Wire—#4 MHD copper (lbs.)	529
Insulators—#44 Locke white	646
Ground rods complete	87
Lightning arresters—G. E. #79,219	204
9. Estimated labor (hours only):	
(a) To dig pole holes	4,880
(b) To gain and shave poles	2,970
(c) To haul poles	2,380
(d) To set poles	3,380
(e) To dig anchor holes	1,695
(f) To erect crossarms	1,750
(g) To erect racks	215
(h) To string wire	11,750
(i) To put on guys	1,400
(j) To erect transformers	2,340
Total Hours	32,760

10. Costs:

(a) Cost of material itemized:

Poles	$16,821.00	
Crossarms	1,474.20	
Crossarm braces	338.80	
D. A. bolts	129.60	
Machine bolts	104.30	
Secondary racks—5 W.	113.80	
Secondary racks—3 W.	47.30	
Toe bolts	91.80	
Brace bolts	64.80	
Round washers	16.20	
Square washers	112.60	
Locust pins	194.40	
Three bolt clamps	237.60	
Guy wire ⅜″ D. G. steel	1,360.00	
Guy insulators	162.00	
Anchor rods	234.00	
Guy hooks	115.01	
Strain plates	194.40	
#4 wire—MHD bare copper	11,620.50	
Insulators—Locke #44	672.00	
Insulators—#355	45.00	
		$34,574.31

(b) Transformer rack materials:

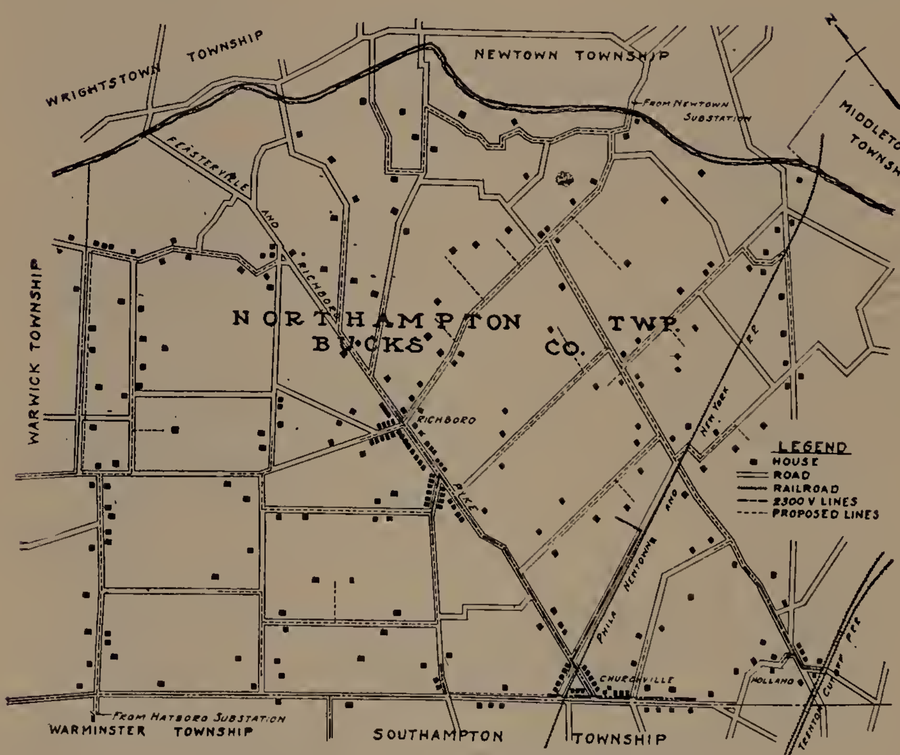
Crossarms—6 pin	$116.28	
Crossarms—4 pin	139.23	
Crossarm braces	61.20	
D. A. bolts	11.90	
Machine bolts	28.90	
Toe bolts	7.65	
Brace bolts	10.20	
Round washers	2.55	
Square washers	20.40	
Locust pins	42.48	
Fletcher pins	83.98	
Ground rods complete	216.63	
Lightning arresters	1,091.40	
Wire—#4 MHD bare	79.35	
Insulators—#44 Locke	103.36	
		$2,015.51
Total all materials		$36,589.82
Total freight, haulage & storeroom expense (10% of total for material)		3,658.98

Total all materials, including freight, haulage, etc.		$40,248.80
(c) Transformers 2300—220/110 volts:		
1½ K. V. A.	473.90	
3 K. V. A.	1,165.68	
5 K. V. A.	3,544.02	
7½ K. V. A.	1,113.71	
10 K. V. A.	1,249.32	
		$7,546.63
Freight, haulage & storeroom expense (5% of total)		377.33
Total for transformers		$7,923.96
Total cost of all materials, including transformers, freight, etc.		$48,172.76
(d) Cost of labor:		
To dig pole holes	$5,040.00	
To gain and shave poles	3,150.00	
To haul poles	2,520.00	
To set poles	3,591.00	
To dig anchor holes	1,800.00	
To erect crossarms	1,750.00	
To erect racks	215.00	
To erect transformers	2,523.00	
To put on guys	1,485.00	
To string wire	12,480.00	
Total labor		$34,554.00

11. Summary of costs:

(a) Cost of right of way:	
(1) No lines to be built on private property, except those serving the owner of the property.	
(2) Pole permits—State Highway	$352.05
(3) Trimming and clearing	2,000.00
Total right of way	$2,352.05
(b) Total cost of all materials, including transformers, freight, etc.	$48,172.76
(c) Total cost of labor	34,554.00
Total	$85,078.81
(d) Cost of engineering (3%) of total for material, labor & right of way	2,552.36
(e) Overheads during construction (2%) of	

total materials, labor and right of way	1,701.58
(f) Cost of engineering reconnaissance	150.00
Total	$89,482.75
(g) Cost of services, including meters:	
(1) 2 W. service (159 services @ $20.96)	3,332.64
(2) 4 W. service (42 services @ $61.79)	2,595.18
Total	$5,927.82
TOTAL COST TO SERVE BUSINESS UNDER THIS CONSIDERATION	$95,410.57



NORTHAMPTON TOWNSHIP, BUCKS COUNTY

12. Services:

(a) This company considers a service as extending from secondary to house bracket. Everything beyond this bracket must be installed by the consumer, with the exception of the meter.

(b) The average length of a service is 80 ft.

(c) Power consumers will have a 4 wire service. Wire to be #4 copper at a minimum spacing of 4 inches.

(d) Light consumers to have a service of #8 duplex wire.

(e) Material required:

(1) 4 wire service
1—#1358 rack
4—#355 insulators
350′—#4 wire
1—25 ampere 220 V. 3 phase meter
1—10 ampere 110 V. 2 wire meter
(2) 2 wire service
1—#109 bracket
2—#8 Locke insulators
80′—#8 duplex wire
1—10 amp. 110 V. 2 wire single phase meter.
(3) Average cost of service including meters:

2 Wire	$20.96
4 Wire	61.79

EXHIBIT NO. 3
PATTON TOWNSHIP, CENTER COUNTY

BY KEYSTONE POWER CORPORATION

SUMMARY

Number of Customers	82
Number of Pole Miles	30.27
Total Cost	$48,588.17
Cost per Customer	593.00
Estimated annual return per pole mile	82.30
Cost per pole mile, 6900 volt construction Chestnut poles	1,610.00
Estimated Annual return per pole mile	82.30
Cost of Service per customer, labor included	66.20
Total Estimated Annual Return	2,492.00
Average span in feet	181
Customers per Pole Mile	2.7
Number of Poles	883
Poles per Mile	29.2
Average height of poles in feet	34.8
Number of Guys	227
Guys per Pole	.26
Number of Transformers	37
Transformers per Pole Mile	1.22
Total Capacity of transformers in KVA	57
Transformer Capacity per Pole Mile in KVA	1.88
Transformer Capacity per Customer in KVA	.7

BUSINESS SURVEY

Number of prospects in all of Patton Township:

Class "A"	1
Class "B"	49

Class "C"	56
Saw Mill (Not Considered)	1
Store & Station	1
Store	1
Church or School House	9
Abandoned Farms	25
Total	143

NUMBER OF PROSPECTS ON LINES PROPOSED

"A" Farms	1
"B" Farms	43
"C" Farms	29
Churches and School Houses	7
Stores	1
Stores and Stations	1
Saw Mills (Portable)*	1
Abandoned Farms*	8

DETAIL OF ESTIMATED ANNUAL REVENUE

1	A	Consumer @ $48.00	$48.00
43	B	Consumers @ 36.00	1,548.00
29	C	Consumers @ 24.00	696.00
7		Churches @ $20.00	140.00
2		Stores @ $30.00	60.00
		Total estimated annual revenue	$2,492.00

ESTIMATED LOAD ON PROSPECTS

Class A		
	House	695 Watts
	Outbuildings	860 Watts
	Appliances	5,871 Watts
	Total	7,426 Watts
Class B		
	House	390 Watts
	Outbuildings	500 Watts
	Appliances	460 Watts
	Total	1,350 Watts
Class C		
	House	170 Watts
	Outbuildings	130 Watts
	Appliances	230 Watts
	Total	530 Watts

*Not considered as to be served.

Store	600 Watts
Church	600 Watts
Store and Station	750 Watts

DETAIL OF LOAD

"A" PROSPECTS

Total Number in Survey 1

PROBABLE CONNECTED LOAD ON AN "A" FARM

Place of Use	*No. and Size of Lamps.*	*Total Watts*
Living Room:		
Reading Lamp	2— 40	80
Ceiling or Wall Fixtures	3— 40	120
Dining Room, Ceiling Fixtures	2— 40	80
Kitchen	2— 40	80
Pantry	1— 40	40
Bedroom	2— 25	50
Bedroom	2— 25	50
Bedroom	2— 25	50
Bathroom	1— 40	40
Porch	1— 40	40
Hall—Downstairs	1— 40	40
Hall—Upstairs	1— 25	25
Total for House		695
OUTBUILDINGS		
Barn—Horse	4— 40	160
Barn—Cow	4— 40	160
Barn—Hay	2— 40	80
Pig House	1— 40	40
Chicken House	4— 40	160
Watering Trough	1— 60	60
Barnyard Entrance	1—100	100
Front Gate	1—100	100
Total for Outbuildings		860
Total for Farmstead		1,555

CLASS "A" PROSPECTS—ELECTRICAL APPLIANCES

	Watts or H. P.	*% of A Farms Having App.*	*No. of Appliances used*	*Load Watts*
Flat Iron	575	70	1	575
Electric Fan	40	2.5	1	40
Cream Separator	½ H.P.	10	1	373
Washing Machine	200	30	1	200
Electric Range	3000		1	3000

	Watts or H. P.	% of A Farms Having App.	No. of Appliances used	Load Watts
Vacuum Cleaner	160	2.5	1	160
Electric Heater	600	4	1	600
Water Pumps	½ H.P.	5	1	373
Toaster	450	10	1	450
Sewing Machine	100	1	1	100
				5871

Total Load.

Average for "A" Prospect 5871 Watts.

CLASS "B" PROSPECTS

Total in survey 49

PROBABLE CONNECTED LOAD ON A "B" FARM.

Place of Use	No. and Size of Lamps.	Total Watts
Living Room	2— 40	80
Dining Room	2— 40	80
Kitchen	2— 40	80
Bedroom	2— 25	50
Bedroom	2— 25	50
Bedroom	1— 25	25
Porch	1— 25	25
Total for House		390
OUTBUILDINGS		
Barn—Horse	2— 40	80
Barn—Cow	4—40	160
Chicken House	4— 40	160
Barnyard	1—100	100
Total for Outbuildings		500
Total for Farmstead		890
Total for 49 Prospects		43,610

ELECTRICAL APPLIANCES—CLASS "B" PROSPECTS—49

	Watts or H. P.	% of Farms Having App.	No. of Appliances used	Load Watts
Flat Iron	575	50	25	14,400
Cream Separator	373	6	3	1,119
Washing Machine	200	18	9	1,800
Electric Range	3,000	1	.5	1,500
Vacuum Cleaner	165	20	10	1,650
Electrical Heaters	600	2	1	600
Water Pumps	373	22	1	373
Toaster	450	5	2.5	1,125
Sewing Machine	100	1	.5	50
				26,617

Appliance Load

Average Appliance Load for "B" Prospect .... 460 Watts

Total Load

Average for "B" Prospect .... 1,350 Watts

Class "C" Prospects

Total in Survey 56

Probable Connected Load on a "C" Farm.

Place of Use	*No. and Size of Lamps*	*Total Watts*
Living Room	2— 40	80
Kitchen	1— 40	40
Bedroom	1— 25	25
Bedroom	1— 25	25
Total for House		170
Outbuildings		
Barn—Horse	2— 25	50
Barn—Cow	2— 40	80
Total for Outbuildings		130
Total for Farmstead		300
Total for 56 Prospects		16,800

Electrical Appliances—Class "C" Prospects—56

	Watts or H. P.	*% of Farms Having App.*	*No. of Appliances used*	*Load Watts*
Flat Iron	575	30	17	9,780
Cream Separator	½ HP			
Washing Machine	200	6	3.4	680
Vacuum Cleaner	165	8	4.5	742.5
Water Pumps	½ HP	1	.6	223.8
Toaster	450	5	2.8	1,260
Sewing Machine	100			
				12,686.3

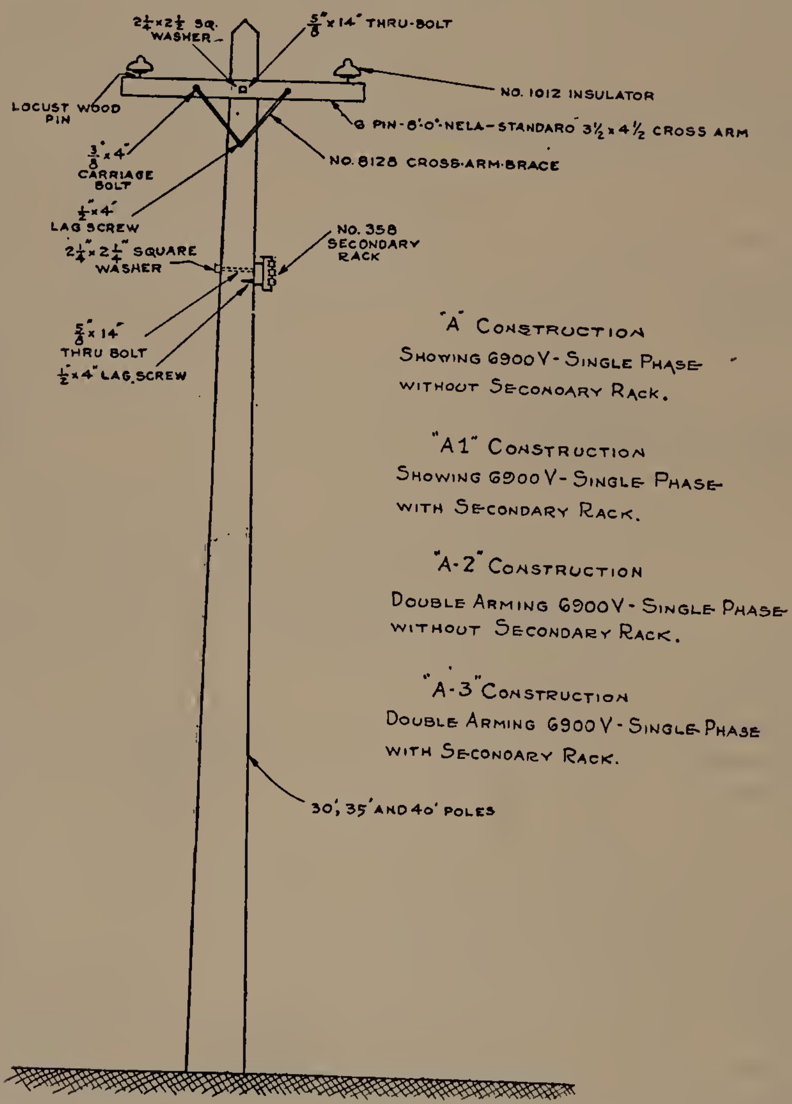
Average Appliance Load for "C" Prospect 230

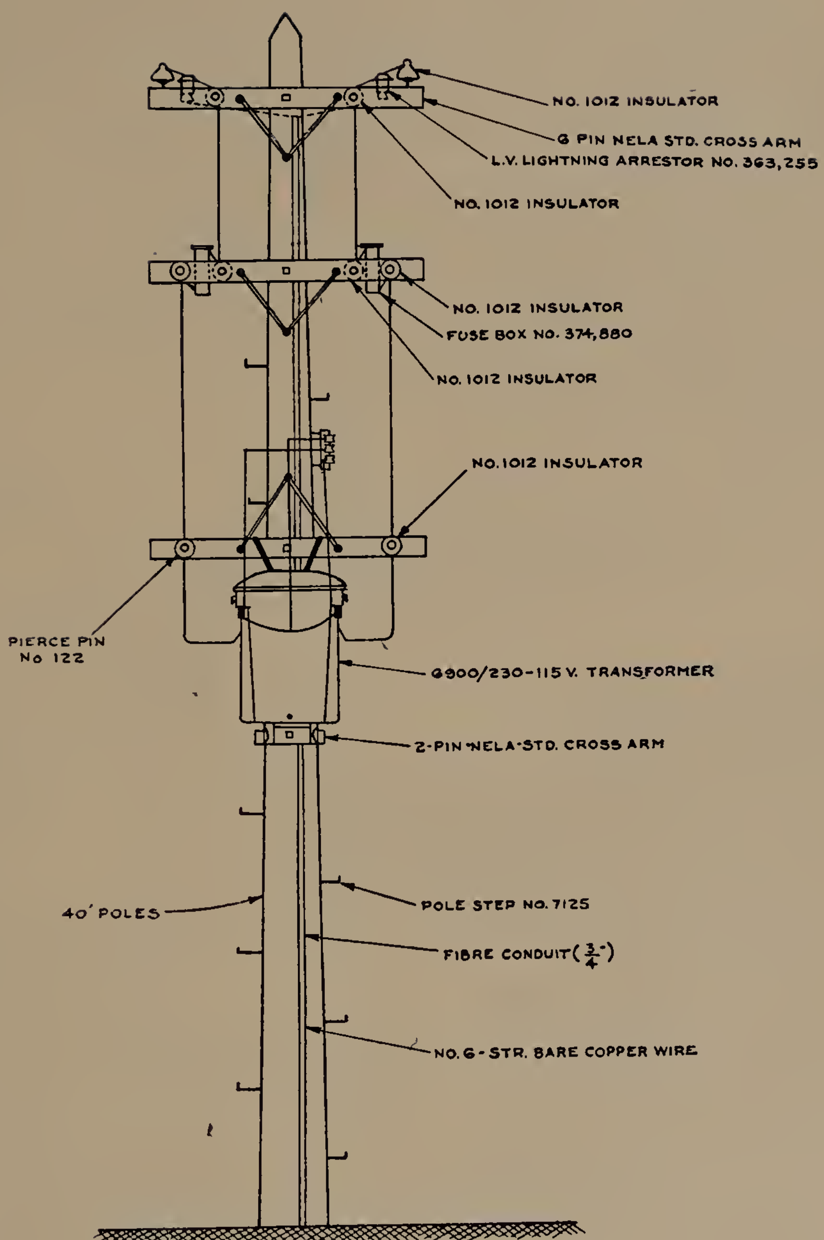
Total Average Load for "C" Prospect 530

Engineering Data

1. Proposed voltage of Primary Lines—6900 Volts.
2. Length of Proposed Pole Line—30.27 Miles.
3. Length of Primary Lines—28.67 Miles.
4. Number of Primary Wires—Two (2) wire—Single Phase.
5. Size of Primary Wires—No. 6 Hard Drawn Copper.
6. Number of Transformers and Size—36—1½ KVA 6900/230—115; 1—3 KVA 6900/230—115.

7. Kind of Poles—Chestnut.
8. Size of Poles—73—40′, 755—35′, 40—25′, 15—30′.
9. Average Normal Spacing of Poles—181 feet.
10. For Location and Spacing of Primary Wires on Poles—See detail drawing Exhibit 3 and 4.
11. Anticipated Max. Demand—20 Kilowatts.
12. Anticipated Load Factor—14.25%.
13. Anticipated Power Factor—40%.





TRANSFORMER POLE CONSTRUCTION
6900V/230-115V

DETAIL OF COST

Cost of Engineering Reconnaissance	$350.00
Cost of Engineering	350.00
Cost of Securing Right of Way	920.00
Cost of Right of Way	1,840.00
Overhead during Construction (5% of material and labor cost. Including 2% interest during construction)	1,844.40
Cost of Freight and Haulage and Stock Record (7% of material cost)	1,355.44
Cost of Material on Transmission Lines (See detail sheet, Exhibit 1)	18,963.63
Cost of Labor on Transmission Line (32,590 man hours)	17,924.50
Cost of Services including Material and Labor (See Exhibit 2)	5,420.20
Total Cost	$49,968.17

COST OF MATERIAL (Primary Lines only)

EXHIBIT No. 1

		Unit Cost	*Total Cost*
15	Chestnut Poles 30′	$4.50	$67.50
40	Chestnut Poles 25′	3.75	150.00
755	Chestnut Poles 35′	5.25	3,963.75
73	Chestnut Poles 40′	6.00	448.00
25800	Lbs. No. 6 Hard Drawn Copper Wire (Bare)	.18	4,644.00
225	Lbs. No. 6 Soft Drawn Copper Tie Wire	.18	40.50
37	2 Pin NELA Std. Cross Arms	.74	27.38
920	6 Pin NELA Std. Cross Arms	1.54	1,416.80
1986	Locust Wood Pins	.03	55.20
2136	No. 1012 Insulators	.41	875.76
2054	Cross Arm Braces #8128	.13	267.02
2054	⅜″ × 4″ Carriage Bolts	.02	41.08
3917	½″ × 4″ Lag Screws	.03	117.51
828	⅝″ × 14″ Through Bolts	.11	91.08
74	⅝″ × 16″ Through Bolts	.13	9.62
73	⅝″ × 18″ Through Bolts	.15	10.95
72	⅝″ × 18″ Double Arming Bolts	.18	12.96
2523	No. 7814 Square Washers (2¼ × 2¼)	.02	50.46
518	No. 7125 Pole Steps	.15	77.70
296	No. 122 Pierce Pins	.22	65.12
74	No. 363255 LV Lightning Arresters	19.80	1,465.20
74	No. 363390 Mounting Brackets	.36	26.64
148	⅜″ × 4″ Machine Bolts	.03	4.42
74	No. 374880 Fuse Box	9.20	680.80
37	Ground Rods	1.00	37.00

37	No. 1769G Ground Points	.28	10.36
37	No. 1763G Ground Caps	.50	18.50
1500′	Fiber Conduit for Ground Wire	.08	120.00
2300′	No.6 Standard RC Copper Ground Wire ..	.03	69.00
36	1½ KVA Transformers 6900/230-115 V. ..	65.10	2,143.60
1	3 KVA Transformer 6900/230-115 V	81.90	81.90
227	No. 32—⅝″ Never Creep Anchors	3.85	873.95
309	No. 536 Strain Insulators	.62	194.67
1164	No. 7461 3-bolt Guy Clamps	.29	337.56
638	No. 7575 Strain Plates	.09	57.12
638	No. 7584 Guy Hooks	.09	57.12
14510′	⅜ Guy Wire	.02	290.20
150	Copper Sleeves	.20	30.00
166	Lbs. No. 6 Str. T. B. Copper Wire	.20	33.20
			$18,963.63

DETAIL OF COST OF SERVICES INCLUDING MATERIAL AND LABOR

EXHIBIT NO. 2

Cost of average service from secondary of transformer to customer's service riser without labor	$41.60
Cost of meter installed	13.60
Average cost of one service	$55.10
Cost of 82 services	$4,518.20
Cost of labor	902.00
Total cost of services including material and labor	$5,420.20

COST OF SERVICES

Q. Average Length of Service from transformer to main switch on consumer's premises.

A. 490 feet.

Q. Average size.

A. No. 6 T. B. W. P. Copper Wire.

Q. Average Spacing of Service Wire.

A. (8″)

Q. Bill of Materials—Quantity Only.

A. See Exhibit No. 6.

Q. Labor—Hours Only.

A. 1640 Man-hours.

Q. Average Size of Meters.

A. 5 amp. 100 volt, 60 cycle, single phase.

Q. Average Cost of Meter Installed.

A. $13.50.

Q. Cost of Average Service Complete from Secondary of Transformer to Customer's service riser.

A. $41.60.

BILL OF MATERIAL

SERVICE-TRANSFORMER TO CONSUMER'S SERVICE RISER

Quantity	*Description*
147	No. 358 Pierce Secondary Racks
147	⅝″ × 14″ Through Bolts
147	No. 7814 Square Washers
311	½″ × 4″ Lag Screws
82	No. 5002A House Brackets
8960	Lbs. No. 6 T. B. W. P. Copper Wire

BILL OF MATERIAL OF TYPICAL "A" POLE CONSTRUCTION

No.	*Description*
1	35′ Chestnut Pole
1	6 Pin NELA Std. Cross Arm
2	Locust Wood Pins
2	No. 1012 Insulators
2	No. 8128 Cross-Arm Braces
2	⅜″ × 4″ Carriage Bolts
1	½″ × 4″ Lag Screw
1	⅝″ × 14″ Thru Bolt
2	No. 7814 Square Washer (2¼″ × 2¼″)

BILL OF MATERIAL OF TYPICAL "A1" POLE CONSTRUCTION

No.	*Description*
1	35′ Chestnut Pole
1	6 pin NELA STD. Cross Arm
2	Locust wood Pins
2	No. 1012 Insulators
2	No. 8128 Cross Arms Braces
2	⅜″ × 4″ Carriage Bolts
2	½″ × 4″ Lag Screws
2	⅝″ × 14″ Through Bolts
3	No. 7814 Square Washers
1	No. 358 Secondary Rack Complete with Insulators

BILL OF MATERIAL OF TYPICAL "A2" POLE CONSTRUCTION

No.	*Description*
1	35′ Chestnut Pole
2	6 Pin Cross Arms
4	4 Locust Wood Pins
4	No. 1012 Insulators
4	No. 8128 Cross Arm Braces
4	⅜″ × 4″ Carriage Bolts
2	½″ × 4″ Lag Screws
1	⅝″ × 18″ Through Bolts
2	⅝″ × 18″ Double Arming Bolts
10	No. 7814 Square Washers (2¼″ × 2¼″)

Bill of Material of Typical "A3" Pole Construction

No.	*Description*
1	35′ Chestnut Pole (Butt Treated)
2	6 Pin Cross Arms
4	Locust Wood Pins
4	No. 1012 Insulators
4	No. 8128 Cross Arm Braces
4	3/8″ × 4″ Carriage Bolts
3	1/2″ × 4″ Lag Screws
1	5/8″ × 18″ Through Bolts
2	5/8″ × 18″ Double Arming Bolts
11	No. 7814 Square Washers (2 1/2″ × 2 1/2″)
1	5/8″ × 14″ Through Bolt
1	No. 358 Peirce Secondary Rack

Bill of Material for Typical "B" Pole Construction

(Secondary Lines Only)

(No Detail Drawing)

No.	*Description*
1	25′ Chestnut Pole
1	358 Secondary Rack
1	5/8″ × 14″ Through Bolt
1	No. 7814 Square Washer
1	1/2″ × 4″ Lag Screws

Bill of Material for Typical Transformer Pole Construction

Quantity	*Description*
1	40′ Chestnut Pole
14	No. 7125 Pole Step
3	6 Pin NELA STD. Cross Arms
1	2 Pin NELA STD. Cross Arm
2	Locust Wood Pins
8	No. 122 Peirce Pin
10	No. 1012 Insulators
6	No. 8128 Cross Arm Braces
6	3/8″ × 4″ Carriage Bolts
6	1/2″ × 4″ Lag Screws
2	5/8″ × 12″ Through Bolts
2	5/8″ ×14″ Through Bolts
9	No. 7814 Square Washer (2 1/4″ × 2 1/4″)
2	L. V. Lightning Arresters Style No. 363255
2	Style No. 363390 Mounting Brackets
4	3/8″ × 4″ Machine Bolts
2	Style 374880 Fuse Box
1	No. 358 Secondary Rack with Insulators
40′	Fiber Conduit
60′	No. 6 Str. R. C. Copper Wire (Ground Wire)

No.	*Description*
1	Ground Rod 6 ft. 1″ Galv. Iron Pipe
1	No. 1769G Ground Point
1	No. 1763G Ground Cap

BILL OF MATERIAL FOR GUY AS PER D. S. No. 302/1—5 PER MILE

No.	*Description*
1	320 ⅝ Never Creep Anchor
1	536 Strain Insulator
4	No. 7861 3 Bolt Guy Clamps
2	No. 7575 Strain Plates
2	No. 7584 Guy Hooks
10	½ × 4 Lag Screws
30′	⅜″ Guy Wire per foot

BILL OF MATERIAL FOR GUY AS PER D. S. No. 305

No.	*Description*
1	25′ Chestnut Pole
1	No. 536 Strain Insulator
4	No. 7461 3 bolt Guy Clamps
4	No. 7575 Strain Plates
4	No. 7584 Guy Hooks
20	½ × 4 Lag Screws
50′	⅜ Guy Wire

BILL OF MATERIAL FOR GUY POLE TO POLE

No.	*Description*
2	No. 536 Strain Insulators
6	No. 7461 3 bolt Guy Clamps
4	No. 7575 Strain Plates
4	No. 7584 Guy Hooks
20	½ × 4 Lag Screws
200′	⅜ Guy Wire

*Foot Note 1. D. S. numbers designate particular drawings associated with the company's standard specifications for line construction.

PATTON TOWNSHIP, CENTER COUNTY

EXHIBIT NO. 4

LEBOEUF TOWNSHIP, ERIE COUNTY
BY ERIE LIGHTING COMPANY

(Controlled by Penn Public Service Company)

This report has been compiled by the Rural Lines Department of the Erie Lighting Company in response to a request of the Giant Power Survey, and has for its object the determining of how far it might be practical to go in the electrification of rural districts. Of the two townships suggested, Venango and LeBoeuf, LeBoeuf was chosen since it was more accessible and seemed to be a more representative area for this particular study.

A map of LeBoeuf Township is made a part of this report, and shows in detail its relative location in Erie County. The nearest large town is Union City and the rural line extension will be made from a substation located at Union City. The population of Leboeuf Township is 1290, of which 1043 is rural and 247 urban, the latter being in the borough of Mill Village which is centrally located in the Township.

A count of the farms, rural schools and churches in the township shows a total of 260 with 70 residences and places of business in Mill Village, a total of 330 possible prospects. There is a total of 62 miles of road in the township and the survey contemplates building lines along 34.4 miles or 53% of the total road mileage. This will reach 198 of the rural homes and schools or a total of 76%. Service is planned for the 70 places in the town of Mill Village so that the proposed lines will serve 81% of the places in the township. In other words 81% of the township can be served by covering 53% of the rural mileage. This leaves 62 places or 19% in the rural districts along the 27.6 miles of road not included in the survey in an area too scattered to even consider serving at this time.

BUSINESS SURVEY [1]

For the purpose of this survey we have divided the rural prospects into the following classes.

(a) Prosperous farmers sure to take current
(b) Average Prospect
(c) Least dependable prospect

Number of Class (a) prospects	36
Number of Class (b) prospects	68
Number of Class (c) prospects	94
Total	198 prospects

Included herewith is a tabulation of each class of prospect showing: [2]

[1] Physical Constants applying to this estimate, not found therein, are given in the general table of Appendix E.

[2] The tabulation referred to is identical except for the addition of a milking machine, with that given in Sub-Appendix A of Appendix E of this report and was therefore not again printed in connection with Exhibit No. 4.

Analysis of connected lighting load

Analysis of connected motor and appliance load.

While this classification may be for the present beyond what we will actually secure, we feel that it is the ultimate to which we must plan and build.

COST OF TRANSMISSION LINES

As shown on the map the line is to be built 2300 V. 6600 V was considered, but due to higher transformer costs and lower transformer efficiency, and since the load can be handled 2300 V, it was decided in favor of 2300 V construction.

BILL OF MATERIALS, LABOR, ETC.

Estimated	*Materials*		*Estimated Cost*
810	30′ poles ....@	$7.50	$6,075.00
15M	No. 4 A. C. S. R. ....@	71.18	1,067.70
60M	No. 6 A. C. S. R. ....@	48.35	2,901.00
10650	lb. No. 4 W. P.		2,130.00
7500	lb. No. 6 W. P.		1,500.00
.6	mile No. 8 ....@	33.29	19.97
1000	4 pin X Arms ....@	1.20	1,200.00
400	3 wire racks ....@	2.30	920.00
2500	½″ × 9″ wood pins ....@	.03	75.00
2500	No. 114 Insulators ....@	.14	350.00
2000	X arm braces 26″ ....@	.08	160.00
4000	Carriage bolts 1½″ × 4½″ ....@	.026	104.00
900	⅝″ × 12″ thru bolts ....@	.072	64.80
100	⅝″ × 16″ thru bolts ....@	.088	88.00
100	⅝″ × 14″ eye bolts ....@	.17	17.00
200	⅝″ × 16″ spacer ....@	.083	16.60
1300	½″ × 3½″ lag screws ....@	.023	29.90
1200	⅝″ square washers ....@	.015	18.00
2000	½ round ....@	.003	6.00
100	anchor rods ....@	.34	34.00
1000′	guy wire ....@	.0198	19.80
200	guy wire insulators ....@	.13	26.00
	Miscellaneous material		1,000.00
126	No. 363254 Lightning arrestors		756.00
	Material Total		$18,578.77

Labor and Right of Way

35	miles engineering ....@	$60.00 per mi	$2,100.00
35	miles right of way		1,050.00
25	miles trimming ....@	50.00	1,750.00
810	holes digging ....@	4.00	3,240.00
810	poles raising and setting ....@	1.50	1,215.00
810	poles gaining and arming ....@	1.00	810.00
35	miles stringing wire ....@	100.00	3,500.00

Estimated			*Estimated Cost*
35	miles hauling material ....@	50.00	1,750.00
35	miles guying poles ....@	40.00	1,400.00
	Miscellaneous labor		3,000.00
	Supervision		2,000.00
	Compensation Insurance		1,407.98
	Total Labor		$23,222.98
Total Labor and Material			$41,801,75

ESTIMATE OF RETURN ON INVESTMENT IN POLE LINE EXTENSION

Character of Investment and New Business	*Estimated Investment and New Business* Ensuing Year 1925	Next Ensuing Year, 1926
Investment		
Cost of Pole and Wire Line (Original)	$38,293.77	$38,293.77
Cost of Service Connections	3,920.00	5,280.00
Cost of Line Transformers	2,865.00	3,580.00
Cost of Meters	1,568.00	2,112.00
Cost of Meter and Transformer Installations	972.00	1,275.00
Cost of Liability Insurance	1,407.98	1,566.98
Cost of Engineering	2,100.00	2,100.00
Total permanent investment	$51,126.75	$54,205.75[1]
New Business		
(1) Street Lighting		
No. of 100 c. p. Lamps, Series Mazda	10	10
Consumption per lamp per year (in Kwh.)	320	320
Hours Burning per Year	4,000	4,000
Total Consumption in K. W. Hours	3,200	3,200
Rate per Lamp per Annum	$26.00	$26.00
Estimated Income (A)	260.00	260.00
(II) Commercial Light.		
No. of Consumers (X)	Rural 140 Towns 56	Rural 198 Towns 68
No. of Lamps (in Kw.) & other load	196 Kw.	266 Kw.
Total Consumption in Kw. Hours	59,100	81,100
Rate per Kw. Hour (In Cents)	9¢	9¢
Estimated Demand (In Kw.)	85 Kw.	106 Kw.
Time of Demand (Month and Hour)	Dec. 8 P. M.	Dec. 9 P. M.

[1]The two following items were stated to constitute a part of the necessary cost of serving LeBoeuf Township but were not included in the estimate.

Cost of Engineering Reconnaissance	$2,313
Cost of Securing Right of Way	200

Estimated Income per Kw. Demand	$62.00	$69.00
Estimated Income (B)	$5,320.00	$7,300.00

(III) Commercial Power

No. of Consumers (X)	1	2
Rated Capacity of Apparatus (In Kw.)	25	50
Total Consumption in Kw. Hours	14,000	28,000
Rate per Kwh. (In cents)	4.4¢	4.4¢
Estimated Demand in Kw.	23 Kw.	46 Kw.
Time of Demand (Month and Hour)	Jan. 20th	Jan. 20th
Estimated Income per Kw. Demand		
Estimated Income (C)	$616 00	$1,252.00
Total Estimated Income (A B C)	$6,196.00	$8,792.00

Number of Unwired Houses, Stores, Etc. along the Proposed Extension:

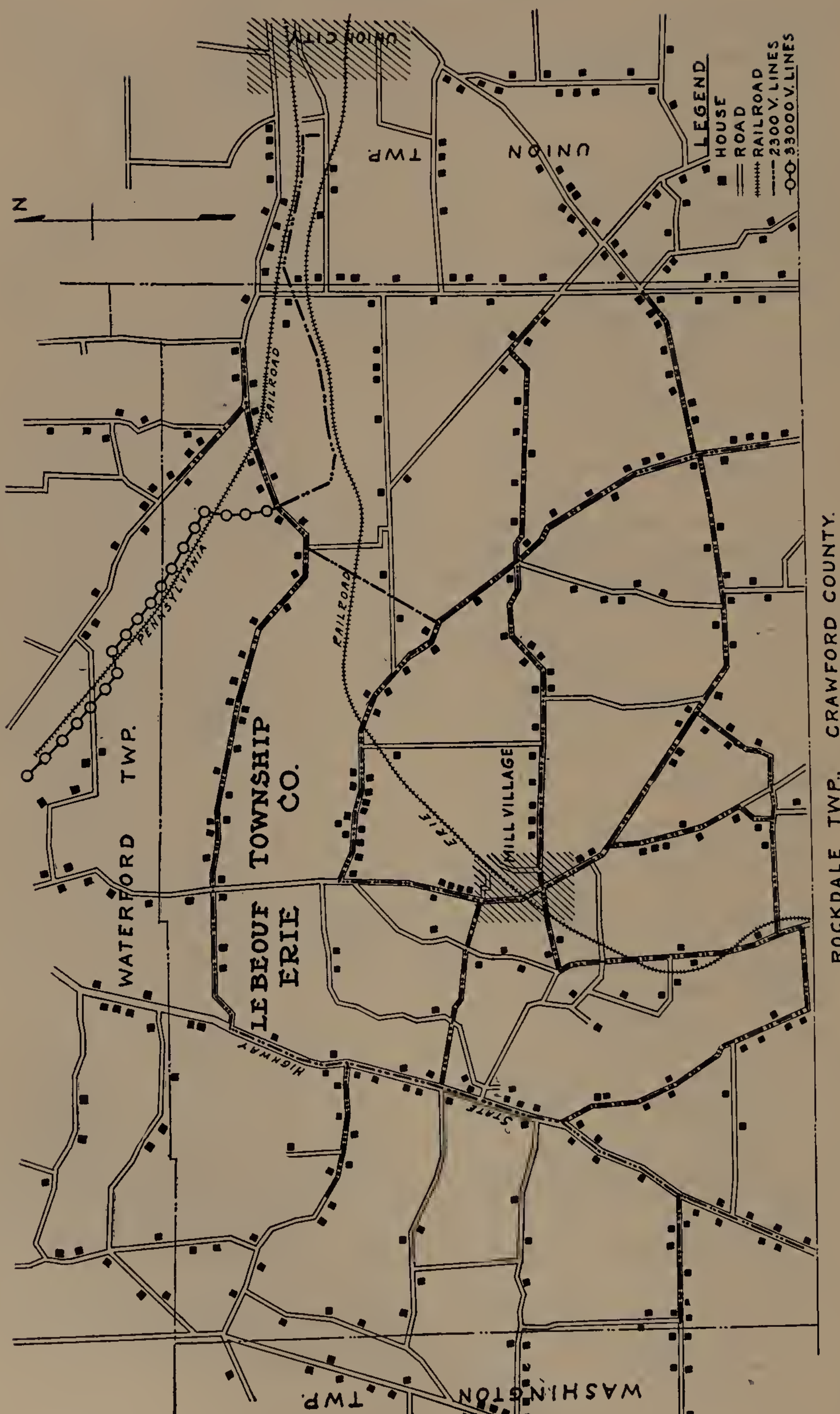
Containing Probable Users	191
Containing Improbable Users	71
Total New Business	268

RATIO OF PROFIT OR LOSS TO INVESTMENT

			Ensuing Year 1925	*Next Ensuing Year—1926*
Estimated Income			$6,196.00	$8,792.00
Expenses				
Operating Expenses				
	Energy Charges	*Customer Charges*		
76,300 Kwh. @ .016 plus [X × $4.50]		$882.00	$2,102.80	
112,300 Kwh. @ .016 plus [X × $4.50]		$1,197.00		$2,993.80
Fixed Charges				
Investment @ 12%				
$51,126.75 Investment @ 12%			$6,135.21	
$54,205.75 Investment @ 12%				$6,504.69
Total Expenses			$8,238.01	$9,498.49
Loss			2,042.01	706.49
Ratio of Loss to Investment			3.9%	1.3%

The year 1926 is based on 100% service which is better than can be expected.

1925 is based on serving 70% of rural customers and 80% of urban homes.



LEBEOUF TOWNSHIP, ERIE COUNTY

EXHIBIT NO. 5

PINE TOWNSHIP ALLEGHENY COUNTY

BY DUQUESNE LIGHT COMPANY

The purpose of this survey was to determine the total number of possible users of electric service in Pine Township, Allegheny County, chosen for us as a typical rural community, to classify them as to the probable extent to which they would utilize service, to estimate the cost of constructing the necessary facilities for serving the community and to estimate the probable revenue and operating expenses on the basis of existing rates.

At present the Duquesne Light Company serves 18 customers in Pine Township, the lines having been constructed to serve summer homes and country estates of several wealthy Pittsburgh families. The estimates therefore, are divided into (a) the cost of existing facilities (b) cost of extension necessary.

SUMMARY

Total number of Customers and Prospects in Pine Township	188
Anticipated Revenue per year	$5,200.00
Estimated Investment in Pine Township exclusively:	
Main Distribution Lines	$41,128.00
Service Lines	17,480.00
Transformers	4,751.00
Meters	1,411.00
Engineering and Contingencies 10%	6,477.00
Present Investment	10,200.00
Total Investment within Pine Township	$81,447.00
Operating Expenses	
Fixed charges on cost of facilities within Township at 11%	$8,959.17
Maintenance and operation at $75.00 per mile	
Present 3.4 miles	255.00
Proposed 25.0	1,875.00
Distribution Losses at $0.015 per Kwh.	
Present	161.46
Proposed	540.00
Total	$11,790.63

The proportion of fixed and operating expense of the Bellevue Substation properly chargeable to Pine Township transmission lines and power station are not included above.

DESCRIPTION OF SURVEY

In making the survey the area was divided into two parts. An automobile with two men was assigned to each part, going over all the roads and spotting all the houses on a map, designating the class of the prospect.

The distances were based on the odometer readings, and are believed to be quite accurate.

A map was prepared from this data showing all present and prospective customers. The average consumption of each customer was estimated from the actual consumption of customers now served by the company in other similar locations. The figures used were as follows:

Class	*Annual Consumption*	*Annual Revenue on Existing rates*
A	746 Kwh.	$48.82
B	373 Kwh.	24.41
C	187 Kwh.	14.96

After the present and prospective consumers had been spotted on the map, a detailed estimate was prepared to show the investment necessary to extend service to all in the township not being served at the present time. Maintenance, operation and losses were then calculated.

Number of Customers and Prospective Customers in Pine Township:

	No.	*Kwh. per Year*	*Revenue per Year*
Present Customers			
Sport Farms	4	18,144	$767.78
Farms	6	2,238	146.46
Residences	8	2,987	195.28
Total	18	23,369	$1,109.52
Prospective Customers			
Class "A"	4	2,984	$195.28
"B"	160	59,680	3,905.60
"C"	6	1,122	89.76
Total	170	62,786	$4,190.64
Total Present and Prospective Customers	188	86,155	$5,200.16

1. Diversity Factors

For rural lines the diversity factor is estimated at 3.

For the extension the 15 minute demand added to the substation load would therefore be:

$$\frac{180}{3} = 60 \text{ KVA.}$$

Including the present transformer capacity serving the 18 present customers the estimated 15 minute demand for the whole township would be:—

$$\frac{270}{3} = 90 \text{ KVA.}$$

2. Cost of Present Lines.

The cost of present equipment in Pine Township is estimated at $3000 per mile or:

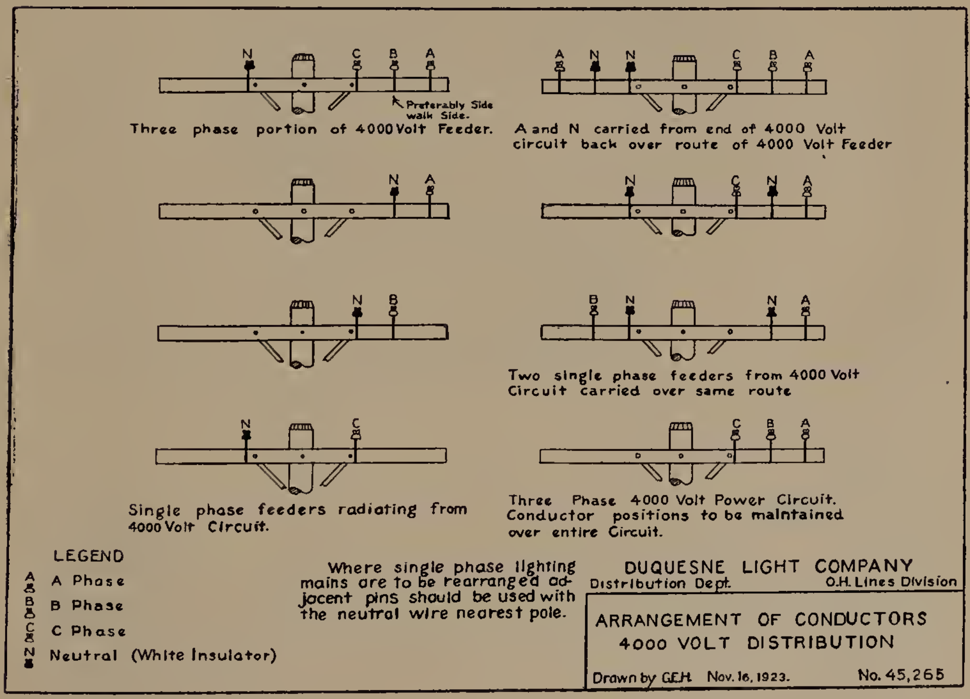
$$3.4 \times \$3000 = \$10{,}200.00$$

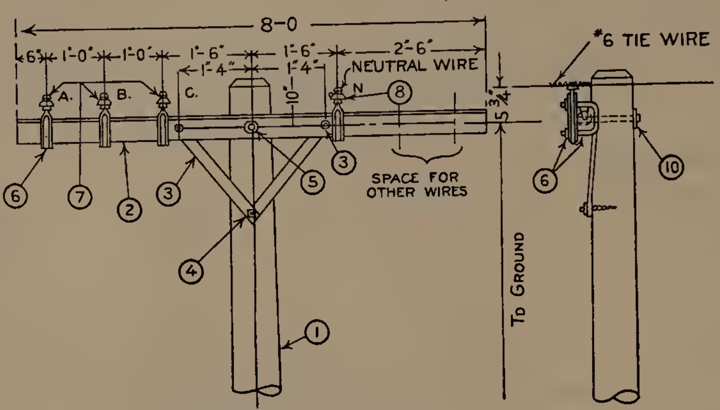
MAIN LINE

1. Poles (Chestnut)		
Guy Stubs	125	$750.00
35′	540	5,805.00
40′	50	750.00
45′	60	1,035.00
Total	775	$8,340.00

NOTE: The 40′ and 45′ Poles are for Crossings.

2. Guys:		
Anchor guys complete	250	$2,125.00
Line Guys	125	937.50
Total		$3,062.50
3. Cross-Arms (Complete)		
8′ X-Arms	250	$675.00
6′ X-Arms	424	1,060.00
Total		$1,735.00





WOODEN CROSS ARM ON WOOOEN POLE

LIST OF MATERIAL FOR ONE POLE

	ITEM	DESCRIPTION	No. REQD.
	1	POLE	1
	2	CROSS ARM-"FIR" 3½"X4½" X 8'-0"	1
	3	" " BRACES 1¼"X¼"X 2'-2"	2
	4	LAG SCREW ½"X 5"	1
	5	MACH. BOLT ⅝"X X"	1
	6	INSULATOR PIN & STRAP-HUBBARD {S-#1002 P-#4401}	4
*	7	INSULATOR LOCKE O.B. 9404 BROWN	3
*	8	INSULATOR " " 9404 WHITE	1
	9	CARRIAGE BOLT ½"-4½"	2
	10	WASHER 2¼X2¼X$\frac{3}{16}$"-FOR ⅝" MACH. BOLT	1

NOTE: ALL METAL PARTS TO BE GALVANIZED.
* ITEMS #7 & #8 TO BE LOCKE #44 FOR #3 & #6 WIRE.

STANDARD
POLE TOP CONSTRUCTION FOR 3φ
4-WIRE-4000 V. SINGLE CIRCUIT
GENERAL
DUQUESNE LIGHT CO.
OFFICE OF CHIEF ENGINEER.

4. Insulators:

No. 44 Insulators	1850	$260.00

5. Wire:

No. 3 H. D. B. Cu. Wire	78,200′	$2,360.40
No. 6 H. D. B. Cu. Wire	283,000′	4,268.00
Total		$6,628.40

6. Miscellaneous Material $700.00

7.	Rights of Way	5,000.00
8.	Labor and Truck Hire	15,402.50
	Total Cost of Main Line	$41,128.00

TRANSFORMERS

1.	50	1 KVA Trans.	$1,000.00
	25	3 KVA Trans.	1,026.00
	9	5 KVA Trans.	510.00
	1	10 KVA Trans.	90.00
			$2,626.00
2.	Transformer Equipment		$850.00
3.	Labor and Truck Hire		1,275.00
	Total Cost for Transformers		$4,751.00

METERS

1.	170—5 Amp. 110 V. Meters	$1,241.00
2.	Labor	170.00
	Total for Meters	1,411.00

SERVICE LINES

1.	340—30′ Chestnut Poles	$2,720.00
2.	340—6′ X-Arms (Complete)	850.00
3.	1020—No. 44 Insulators	143.00
4.	135,000′ No. 6 H. D. B. Cu Wire	2,025.00
5.	49,600′ No. 3 W. P. Wire	1,984.00
6.	600—No. 350 Brackets	384.00
7.	1,200—No. 5 Insulators	84.00
8.	170—2 Point Brackets	50.00
9.	34,0000′ No. 6 W. P. Wire (Service Lines. (Last Pole to House)	680.00
10.	Miscellaneous Material	437.00
11.	50—Anchor Guys	425.00
12.	Labor and Truck Hire	7,698.00
	Total for Services	$17,480.00

SUMMARY

1.	Main Line	
	Average Span	200′
	Poles per Mile	27 (Approx.)
	Cost per Mile	$1,630.00
	Cost per Customer	238.00
2.	Service:	
	No. Customers	170

Poles per Customer	2 (400′ Average dist.)	
Cost per Customer	$102.00	

NOTE: Service indicates taps from main line to customer which are in many cases 2300 V.

3. Transformers:

Customers per Trans.	2	
KVA per Customer	1	
Cost per Customer	$28.00	

4. Meters:

Meter per Customer	1	
Cost per Customer	$9.00	
Total Cost of Proposed Line		$64,770.00
Engineering and Contingencies 10%		6,477.00
Grand Total		$71,247.00
Total Cost per Mile		$2,850.00
Total Cost per Customer		420.00

NOTE: Total cost per mile was determined by dividing Grand Total by 25 Mi. or total length of main line.

DISTRIBUTION LOSSES ON EXTENSION IN PINE TOWNSHIP

METERS

Average loss per meter per mo.	0.80 Kwh.
Total loss 170 meters	136.0 Kwh.

TRANSFORMERS

Number	*Size*	*Loss per Transformer per Month*	*Total Loss per Month*
50	1 KVA	20 Kwh.	1,000 Kwh.
25	3 KVA	35 Kwh.	875 Kwh.
9	5 KVA	48 Kwh.	432 Kwh.
1	10 KVA	82 Kwh.	82 Kwh.
Total Transformer Losses per Month			2,389 Kwh.

LINE LOSS

Twenty-five miles distribution lines and service drops	475 Kwh.
Total distribution losses within Pine Township per month	3,000 Kwh.
Total losses per year	36,000 Kwh.
Loss per year at $0.015 per Kwh.	$540.00

1. Maintenance—$29.00 per mile

As distance from operating headquarters increases, add 2% for each additional mile in excess of 3 miles.

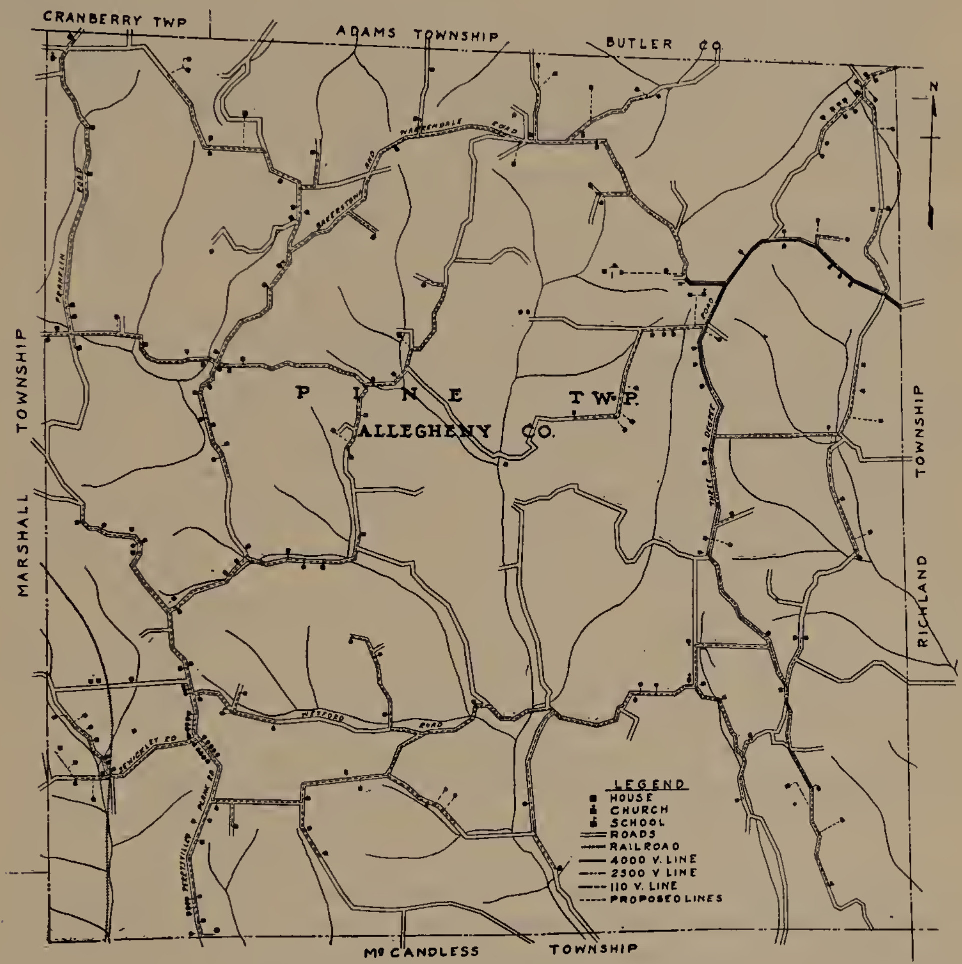
2. Operation:

$11.00 per mile } (2 Transformers/Mile) (6 Customers/Mile)

Add 2% per mile for each additional customer and transformer, also 2% for each mile in excess of three (3) miles from operating headquarters.

There are 25 miles of main line, 85 transformers and 170 customers.

If this line is operated from Bellevue Office, the operation and maintenance will be $75.00 per mile per year.



PINE TOWNSHIP, ALLEGENY COUNTY

PRESENT DISTRIBUTION SYSTEM IN PINE TOWNSHIP AND LOSSES

	Number	*Loss per Month*	*Total Loss per Month*
Meters	22	0.80 Kwh.	17.00 Kwh.
Transformers:			
15 KVA.	3	111.00 Kwh.	333 Kwh.
10 KVA.	3	82.00 Kwh.	246 Kwh.
7½ KVA.	1	65.00 Kwh.	65 Kwh.
5 KVA.	2	48.00 Kwh.	96 Kwh.

3 KVA.	2	35.00 Kwh.	70 Kwh.
1 KVA.	1	20.00 Kwh.	20 Kwh.
Distribution lines 3.4 miles			50 Kwh.
Total losses per month			897 Kwh.
Total losses per year			10,764 Kwh.
Loss per year at $0.015			$161.46

There followed, in Exhibit No. 5, as originally presented, a Classification of Prospective Customers which is identical with that in Sub-Appendix "A" of Appendix "E" and is therefore not repeated here.

VOLTAGES OF LINES

The voltages of lines shown on the accompanying map of Pine Township are as follows:

Present 4 wire main line—4000 V., 3 Phase.

Proposed 4 wire main line—4000 V., 3 Phase.

Present 2 wire main line—2300 V., Single Phase.

Proposed 2 wire to form 4 wire main line—2300 V., Single Phase, to be changed to 4,000 V., 3 Phase.

Proposed 2 wire main line—2300 V., Single Phase.

Present 110 V. bank.

Present Service—110 V.

Proposed Service 110/220 V.

EXHIBIT NO. 6

MENNO AND UNION TOWNSHIPS, MIFFLIN COUNTY

BY PENN CENTRAL LIGHT AND POWER COMPANY

The territory surveyed covers roughly twenty-five square miles and is in shape a parallelogram six and one quarter miles long by four miles wide, extending in a northeasterly and southwesterly direction. The northeastern boundary is a line drawn through the southwestern edge of the town of Belleville, while the southwestern boundary is a line drawn through a point a short distance northeast of the town of Allensville. The northwestern and southeastern boundaries are Standing Stone Mountain and Jack's Mountain, respectively.

The valley lying between Stone Mountain and Jack's Mountain within the limits set forth is rolling country about ninety-five percent cultivated. The only timber within the area lies at the bases of the two mountains at the extreme longer edges of the surveyed portion. State Highway Route No. 192 passes through the center of the valley at the towns of Allensville, Menno and Belleville. There is no steam or electric railway within the limits of this survey.

CHARACTERISTICS OF THE TERRITORY

Practically all the farms within the area surveyed are of a very high standard. Up-to-date machinery and equipment are used in farming; and by-roads and lanes are kept in repair as are fences and gates. A high percentage of the farm houses are brick and to a great extent barns, chicken houses, stables and the like are painted and kept in excellent repair.

Possibly ninety-five percent of the farms within this area are owned by people of the Amish faith. It was not until a few years ago that members of this faith were permitted to use electric current and after several years of use the connected load has grown very slowly and the use of current has been exceedingly low.

Within the area of this study there are thirty-two customers served from a 2300 volt single phase line under a single circuit three phase 45,000 volt transmission line, known as "D" line. For the purpose of this survey neither of these lines is treated as existing so far as distribution is concerned but in the classification of farm customers as to connected load, the data this company has in its files on connected load, has been used. From this it appears that the average connected load for even the most prosperous farms, considering both lighting and appliance loads, is 1.8 kilowatts and for the less prosperous farms .5 kilowatts. All the farms surveyed, therefore, fall within either the "B" or the "C" class as outlined in the Survey Board's general classification as to respective equipments. It has been thought best to use the classification submitted in order that this report may tie in with others, rather than to lay down rules applicable to Penn Central territory alone. Likewise since no mention is made of power in the Survey Board's classification, this item has been neglected in this report. This seems logical also on account of the wide variation in the use of power and the fact that if considered, the average figures arrived at might be considerably distorted. Of the thirty-two users of electric current within this area, only seven have motors and the largest of these motors is a 7½ H. P. the others being less than 2 H. P.

The only business within the area considered other than the farms is the small settlement of Menno and a few scattered dwellings, churches and schools. Where an individual dwelling or building does not fall within the distribution system laid out for the farms it has been treated as a "sport" and has been disregarded.

Since the area under consideration is uniformly covered by farms, the distribution system as laid out includes all the farms within the area and the study therefore is for 100% saturation.

BUSINESS SURVEY

Number of Prospects:

(a) Prosperous farms sure to take current.

None

(b) Average prospect.
106

(c) Least dependable prospects.
24

(d) Dwellings, churches, schools, enroute.
43

Probable Consumption of Energy:

(a) Class "A" Prospects.
Unknown

(b) Class "B" Prospects
238 kilowatt hours per annum

(c) Class "C" prospects.
112 kilowatt hours per annum

(d) Class "D" prospects.
Same as Class "C"

PHYSICAL CONSTANTS OF PROPOSED LINES

Proposed Voltage of Primary Lines
2300 volts

Length of Primary Lines
161,700 feet

Length of Proposed Pole Lines
208,560 feet

Number of Primary Wires and size
2 No. 8 Hard Drawn copper wires on single cross arm

Number, Size and Location of Transformers
29—½ K. V. A. 2300/110
27—1½ K. V. A. 2300/110
6—3 K V. A. 2300/110
4—5 K. V. A. 2300/110

Size and kind of poles:
25 ft., 30 ft., and 35 ft., Chestnut Poles
A few 40 ft. poles for grading (see bill of material)

Spacing of Poles:
150 feet

Location and Spacing of Primary Wire on Pole:
On yellow pine cross arms 3¼ × 4¼ × 36. Wires spaced 30 inches.

Anticipated Maximum Demand:
67 kilowatts

Anticipated Load Factor:
2% (connected load factor)

Anticipated Power Factor:
85%

ESTIMATED COST OF EXTENSIONS

Cost of Engineering Reconnaissance:
$75.00

Cost of Engineering:
$1985.04

Cost of Securing Right of Way:
$300.00

Cost of Right of Way:
$1500.00 (includes property damages)

Overheads during construction:

Liability Insurance	$995.50
Overhead Stores Expense	1,584.65
Overhead Planning Expense	702.70
Total	$3,282.85

Cost of Freight and Haulage:

Poles	$2,200.00
Arms and Hardware	800.00
Wire	72.00
Transformers	132.00
Lightning Arresters	10.00
Service Material	200.00
Meters	100.00
Fuse Boxes	15.00
Total	$3,529.00

Cost of Material Including Transformers:
See attached sheet.

Cost of Labor:
$23,423.47

COST OF SERVICE

Average Length of Service from Transformer to Main Switch on Consumer's Premises.
100 feet span, 200 feet wire.

Average Size and Spacing of Wires.
No. 10 Weather Proof Wire, spaced 9 inches.

Bill of Materials, Quantities only:
See following tables.

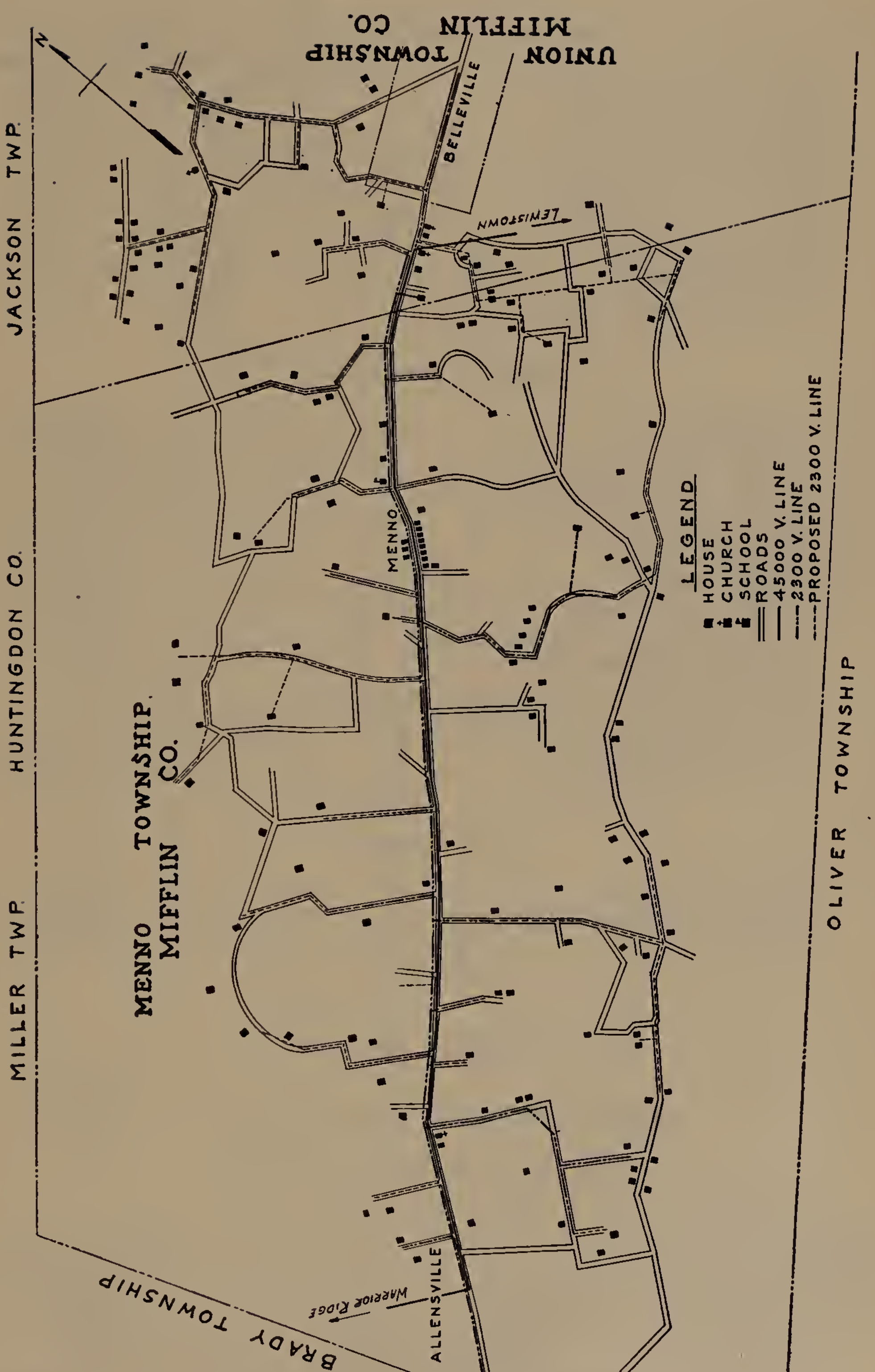
Labor, Hours only:
See following tables.

Average Size and Cost of Meter Installed:
Average size, 5 ampere.
Cost, $7.88.

Cost of Average Service Complete from Secondary of Transformer to Main Switch in Consumer's Premises.
$18.00.

ESTIMATE OF COST OF MATERIALS

275	25 ft. Poles @ $4.00	$1,100.00
640	30 ft. Poles @ 6.00	3,840.00
458	35 ft. Poles @ 8.00	3,664.00
55	40 ft. Poles @ 12.00	660.00
1,275	3¼x4¼x3′ 4. P. arms 75% heart @ 32¢	408.00
200	7/32x1 7/32x24″ galv. braces @ 09¢	18.00
200	⅜x4½ galv. car bolts @ 02¢	4.00
100	½x4 galv. lags @ 03¢	3.00
1,075	⅝x12 through bolts g. @ 08¢	86.00
100	⅝x16 through bolts g. @ 11¢	11.00
2,350	⅝ galv. Washers @ 01¢	23.50
2,550	Locust Pins @ 03¢	76.50
2,550	No. 592 Lapp insulators @ 26¢	663.00
525	3 pt. racks @ $1.34	703.50
525	⅝x10 Through Bolts @ 07¢	36.75
525	⅝ Washers @ 01¢	5.25
525	½x4 Lags @ 03¢	15.75
10,000	ft. 5/16″ stranded steel guy wire @ .017¢	170.00
500	3 bolt guy clamps @ 18¢	90.00
200	⅝x8 Anchor Rods @ 53¢	106.00
200	½″ Guy Thimbles @ .063¢	12.60
50	Guy Stubs, Chest. @ $4.00	200.00
200	Anchor Logs @ $2.00	400.00
161,000	ft. or 18,032 lbs. #6 W. P. Wire @ 18¢	3,245.76
323,400	ft. or 16,170 lbs. #8 Bare H. D. Wire @ 18¢	2,910.60
50	Rolls Friction Taps @ 15¢	7.50
29	½ KVA-2300-110 v. transf. $14.00	406.00
27	1½ KVA-2300-100 v. transf. $29.91	807.57
6	3 KVA-2300-110 v. transf. $46.04	276.24
4	5 KVA-2300-110 v. transf. $61.09	244.36
20	3¾x4¾x6′ YP 75% heart arms @ 72¢	14.00
40	¼x1¼x28″ Braces @ 19¢	7.60
40	⅜x4½ Car Bolts @ 02¢	.80
20	½x4 Lags @ 03¢	.60
60	⅝x18 Thru Bolts @ 12¢	7.20
40	No. 71 Pierce Pins @ 12¢	4.80
40	No. 48 Insulators, 592L. @ 26¢	10.40
20	2300 v. light. arrest. @ $5.32	106.40
20	100 A Choke Coils @ $4.46	89.20
10	2″x8′ ground Pipes @ $2.83	28.30
5	Bu. Coke @ 30¢	1.50
50	Lb. Rock Salt @ 01¢	.50
350	Ft. #2 S. D. Bare Wire @ 04¢	14.00
30	No. 2 Terminals @ 06¢	1.80



Menno and Union Townships, Mifflin County

Bill of Material for Services

173	2 Pt. Wire Holders
519	1 Pt. Wire Holder
17,300	ft. or 917 lbs. #10 W. P. Wire
15	Rolls Friction Tape
692	15 amp. Fuse Plugs
173	5 amp. 100 v. Meters
173	Meter Boards
173	Meter Trims
60	Porc. Fuse Blocks

Labor on Pole Lines

	Hours
Dig 1428 Holes	14,280
Frame and Raise 1428 Poles	14,280
Dig 200 Anchor Holes	2,500
Dig 50 Guy Stub Holes	500
Place 250 Guys	273
Deliver Material	600
String and Tie 323,400 ft. #8 Bare	2,310
String and Tie 161,000 ft. #6 W. P. Wire	1,840
Make taps at Junction Poles	115
Place and Connect 66 transformers on poles	507
Place Lightning Arresters Choke Coils and Grounds for 10 trans-installation	115
Place 60 Fuse Boxes	70

Labor on Services

Place 173 Services	663
Place and Connect 173 Meters	288

EXHIBIT NO. 7

TILDEN TOWNSHIP, BERKS COUNTY

By Metropolitan Edison Company

General Statistics

Total Area of Township	19.99 sq. miles
Unoccupied Area	5.65 sq. miles
Total Road Mileage in Township	45.65 miles

Business Survey

Based upon the classification suggested by the Giant Power Survey,

with the exception of the prospective use of appliances; our experience being that fewer appliances would be used.

NUMBER OF FARM PROSPECTS:

Class "A"—Good prospect	44
Class "B"—Average prospect	44
Class "C"—Least dependable prospect	49

PROBABLE CONSUMPTION OF ENERGY:

Class "A" prospects	300 kwh. per annum
Class "B" prospects	150 kwh. per annum
Class "C" prospects	100 kwh. per annum

PHYSICAL CONSTANTS OF PROPOSED LINES

Proposed voltage of main feeder line	13,200	volts
Proposed voltage of primary lines	2,300	volts
Length of proposed pole lines	36.65	miles
Length of main feeder	3.60	miles
Length of primary lines	23.35	miles
Number of main feeder wires and size	3-#4	copper
Number of primary wires and size	2-#6	copper
Size and kind of poles:		
30′ cedar predominating for 2300 volt and 110/220 volt lines.		
40′ cedar predominating for 13,200 volt line.		
Spacing of poles	135	feet
Location and spacing of primary wires:		
Location—On top of crossarm except where 13,200 volt wires are above.		
Spacing—28″		
Anticipated maximum demand	30	kw.
Anticipated load factor—yearly	10%	
Anticipated power factor—at time of evening peak	85%	
24 hour average	45%	

13,200—2300 VOLT TRANSFORMERS

Location	*Size*
T a	15 K. V. A.
T b	15 K. V. A.
T c	15 K. V. A.

Total Number
3—15 K. V. A.

2300—230/115 VOLT TRANSFORMERS

Location	*Size*	*Location*	*Size*
T 1.	1.5 K. V. A.	T 21.	1.5 K. V. A.
T 2.	3. "	T 22.	1.5 "

Location	*Size*	*Location*	*Size*
T 3.	1.5 K. V. A.	T 23.	1.5 K. V. A.
T 4.	3. "	T 24.	1.5 "
T 5.	1.5 "	T 25.	1.5 "
T 6.	1.5 "	T 26.	1.5 "
T 7.	1.5 "	T 27.	3. "
T 8.	1.5 "	T 28.	1.5 "
T 9.	3. "	T 29.	3. "
T 10.	3. "	T 30.	1.5 "
T 11.	1.5 "	T 31.	3. "
T 12.	3. "	T 32.	3. "
T 13.	3. "	T 33.	1.5 "
T 14.	1.5 "	T 34.	3. "
T 15.	3. "	T 35.	1.5 "
T 16.	3. "	T 36.	3. "
T 17.	1.5 "	T 37.	1.5 "
T 18.	1.5 "	T 38.	1.5 "
T 19.	1.5 "	T 39.	1.5 "
T 20.	1.5 "	T 40.	1.5 "

Total Number

26—1.5 K. V. A.

14—3.0 K. V. A.

BILL OF MATERIALS
(Including Service Wires to Buildings)
For 137 Prospects

	Quantity
40′ Cedar poles	159
30′ Cedar poles	1,455
7′6″x¼″x3½″x4″ steel angle arms	205
4—pin wood cross arms	80
2—pin wood cross arms	1,205
3—wire secondary racks G2733	899
Angle Iron U-braces	205
¼″x1¼″x28″ galv. iron braces	2,570
⅝″x12″ thru bolts	1,926
⅝″x14″ thru bolts	891
⅝″x18″ thru bolts	217
⅝″x18″ spacer bolts	434
⅝″x4″ lag bolts	1,490
⅝″x1½″ machine bolts	410
⅝″x4″ machine bolts	24
½″x4″ carriage bolts	2,570
⅝″ square washers	4,121
½″ round washers	2,570
⅝″x6′ copper ground rods	239
10′ pcs. wood moulding for ground wire protection	239
Staples	99.5 lbs.

	Quantity
Pole Steps	430
⅜″ galv. iron guy wire	33,900 ft.
⅝″x6′ anchor rods	204
3 bolt clamps	724
⅜″ thimbles	724
#502 strain insulators	362
Keystone truss pins #44242	561
Locust shell pins	2,496
15,000 v. porcelain insulators Thomas 2125	561
3000 v. porcelain insulators	2,496
#4 bare copper H. D. wire	11.88 Mi.
#6 T. B. W. P. wire	124.14 Mi.
#8 T. B. W. P. wire services	5.19 Mi.
#6 solid bare wire	0.60 Mi.
Transformers—15 K. V. A., 60 C., 13,200/2,300 V.	3
Transformers—3 K. V. A., 60 C., 2300/230-115 V.	14
Transformers—1.5 K. V. A., 60 C., 2300/230-115 V.	26
Elpeco combination fuse and disconnecting switch 15,000 V., 1 to 25 Amp., Cat. #0761	6
Sweitzer & Conrad fuses, 5 amp., 15,000 V.	6
Compression chamber lightning arresters for 2300 V.	80
G. E. fuse cut-outs for 2300 V.	80
Solder	222 lbs.
Soldering paste	2 lbs.
Tape	300 lbs.
Gasoline	78 gal.
#6 ties and jumper wires	1100 lbs.

ESTIMATED LABOR

Total number of man-hours, not including truck time	49,800

SERVICE DATA

Average length of service from pole line to consumer's building	100 feet
Average size of wire	No. 8
Average size of meter installed	5 & 10 Amp.

POWER FACTOR DATA OF A NEARLY TYPICAL RURAL LINE

MERTZTOWN LINE EXTENSION

Average Conditions over 24 Hour Period

Volts	4,800
Amperes	1.42
Volt Amperes	6,816
Watts	3,100
Average Power Factor	45.5%

MAXIMUM DEMAND PERIOD (15 minutes)

Volts	4,760
Amperes	2.98
Volt Amperes	14,130
Watts	12,000
Power Factor	84.6%
Total 24 hour consumption	74.4 kwh.
Total number of consumers including 36 farms; balance rural and town residences	80

TILDEN TOWNSHIP, BERKS CO.

EXHIBIT NO. 8

POLE LINE CONSTRUCTION IN

MENALLEN TOWNSHIP ....ADAMS CO.
TILDEN TOWNSHIP ....BERKS CO.
NEW BRITAIN TOWNSHIP ....BUCKS CO.

BY BELL TELEPHONE COMPANY

The information requested by the Giant Power Survey, which the telephone company volunteered to supply, is the cost of the pole lines which would be required to provide telephone service to the rural residents of the State, with a view to determining the most economical method of serving these same rural residents with electrical energy.

The detailed carrying out of the investigations necessary was accomplished by joint surveys carried on by engineers from the Giant Power Survey and from the telephone company.

SCOPE OF SURVEY:

Typical townships were suggested by the engineers of the Survey and and surveys were made of these. The surveys had as their object:

A—A personal knowledge of typical rural districts in order to record data relative to:

1. Approximate number of farms per mile of highway.
2. The extent of present telephone pole lines and, in general, the character of these lines.
3. The extent of present electric light and power lines, and in general, the character of these lines.

B—The preparation of a hypothetical design of a pole line system to supply service to all farms in the district covered:

1. From the point of view, first, that these poles shall support only telephone wires.
2. That the poles shall be suitable for use jointly by a telephone and an electric light company in supplying their services to all farms.

In the securing of data in the field, large scale maps of the townships were used for recording approximate farm locations; locations and general character of telephone lines, including the length of poles, whether bracket or crossarm construction, and the number of wires; and data relative to electric light lines, including location on highways and general character of lines.

No attempt was made to classify farm homesteads as prospective customers of either telephone or electric light service. It was the purpose of the survey to determine the class of poles suitable and not to determine the availability of present plant either for the use of the telephone company or the power company.

TOWNSHIPS SURVEYED:

From a list of townships located at representative sections of the State,

the Giant Power Survey Engineers selected, as being not only of varying types, but also within reasonable automobile distances from Philadelphia and Harrisburg:

Menallen Township in Adams County (South Central Section)
Tilden Township in Berks County (Northeast Section)
New Britain Township in Bucks County (Southeast Section)

POLE LINE LAYOUTS:

In the study of pole layout to supply only telephone service, the location or locations of central offices in which the lines terminated were assumed. Changes in these locations would necessarily affect the hypothetical layout and the number of poles required. In as far as practical, existing central offices were used as reference points, and the routes requiring the least number of poles were selected. Poles along highways only were estimated, no attempt being made to estimate the additional number of poles that would be required from highway limits to points of attachment on farm buildings. The inclusion of these poles would make an appreciable addition to the total number of poles used.

POLE SIZES:

Required pole sizes are determined by the service for which used and should be in conformity with recognized specifications governing such use.

The height of the pole is determined by the required clearances of wires above ground and roadways. The accepted practice for rural telephone lines is:

1. Where the line runs along the side of highway, street road or alley, the minimum clearance is:

(a) In rural districts—13 feet.

(b) In other districts—18 feet.

Where the location relative to ditches, fences and embankments is such that the ground underlying will be traveled by pedestrians only—8 feet clearance is required. This condition does not apply, however, to anchor guys or communication conductors of over 160 volts to ground and 50 watts capacity.

2. Where parts of the lines project or cross over traveled portions of highways used by vehicles, the clearance is 18 feet.

3. Wire crossings of driveways in rural districts require the clearance of wires above ground to be 18 feet.

For the rendering of telephone service alone in such territories as were covered in the surveys, practice has shown that, in order to carry the necessary number of wires, a twenty-five (25) foot, Class "E" pole adequately meets our needs for the major portion of the distances as generally but from two (2) to six (6) wires constitute the requirements for service in such rural districts. These wires are supported by a crossarm or by brackets.

While thirty (30) foot poles might be required in the vicinity of the central office, it would also be practical to use many twenty (20) foot, Class "F" poles where but two wires are supported. To equalize as nearly

as possible the approximate cost of these different classes of poles in the hypothetical layout, twenty-five (25) foot, Class "E" poles have been assumed in the telephone plant where their uses are restricted to telephone purposes only.

NOTE: For classification of types of poles, see Appendix "B".[1]

From the required clearances above ground as above described, it is evident that for major portions of country highways, the location of poles along fence lines or otherwise off vehicle-used portions of the highways, permit signal companies to use small poles—of 20 or 25-foot lengths.

JOINT USE

In the preceding paragraphs consideration has been given to the size of poles required to carry telephone circuits only. It is possible to secure certain advantages and economies through the joint use of poles for carrying telephone and power conductors, provided the construction standards which have now become well established are adhered to. Standards have been developed and are in effect for joint use of poles by telephone subscriber circuits and power circuits not in excess of 5000 volts A. C.

In determination of the size of the poles required for joint construction, the governing factors are the strength requirements, which control the class of pole to be used, and the requirements for clearances above ground and between circuits of various classes, which determine the heights. Where one crossarm each of power and telephone circuits are required, a 30′ Class "C" pole is called for, and where more than this is required, not less than a 35′ Class "C" pole is called for.

Crossings over railroads and additional height required by tree conditions will necessitate poles of greater length.

The survey was made primarily to analyze the theoretical saving in poles alone if, in developing rural sections of the State for telephone and electric light services, one set of poles could be used by both services rather than separate pole lines.

Conditions will arise where it will not be practical to employ poles for joint use by telephone and electric light companies. The principal reasons for this are:

(a) Character of telephone circuits involved.

(b) Character of supply circuits involved.

(c) Where an existing telephone line adequately meets the needs of service requirements and is capable of giving years of service, it may be uneconomical to abandon those poles for poles suitable for joint use purposes, provided there is a right of way available for an electric light line on the opposite side of the highway.

(d) Due to the greater strength of electric light construction than that of telephone construction, the employment of greater span lengths in electric light pole lines might prove of sufficient importance to justify separate pole lines in certain localities.

---

[1]Appendices A, B and C referred to in Exhibit 8, are all included in the exhibit itself which is, in turn, a part of the general appendix E.

Generally, however, where new territory is to be developed for both telephone and electric light services, or where existing telephone poles are scheduled for early replacement, it will be found advantageous to consider the joint use of poles, unless made impractical as above outlined in (a), (b) and (d). Consideration of each case of rural development should be carefully analyzed by the representatives of both interests.

POLE COSTS

Appendix "A" covers the costs of poles used in this analysis. These costs cover poles of different grades and lengths in different sections of Pennsylvania.

In making the cost estimates, we have used, as being most dependable, prices based on our recent experience in pole work. The work was actually performed by our forces and was in accordance with our current standards of quality and practice. These standards represent the results of years of experience and we are convinced that any lowering of these standards as applied to first costs will prove uneconomical, due to the increase of maintenance charges and in an inferior quality of service.

These costs have been summarized for Eastern Pennsylvania, the Harrisburg Division (embracing the central part of the State) and Western Pennsylvania. An average cost for the entire State would be approximately the average of the three values shown.

Note: The definitions of the cost items and the tables of costs are given in Appendix "A."

From the unit costs as shown in Appendix "A" and the number of poles required as obtained from the survey maps in Appendix "C," the following tables of costs have been made up both for telephone use alone and for joint use with electric light and power circuits.

The number of poles required was determined from the length of the pole line without taking into account actual road crossings, corners and bad tree conditions that might be encountered as the costs were required largely for comparative studies. Based on the number of poles required which are assumed to be the same whether jointly used or not the costs are:

TELEPHONE USE ONLY

ITEM	TOWNSHIPS		
	Menallen	*Tilden*	*New Britain*
No. of poles required	987	665	1,292
Unit Cost—25′ Class "E" Pole	$15.29	$15.29	$12.13
Total cost poles erected	15,091.00	10,168.00	15,672.00
Man Hours per pole	7.31	7.31	4.89
Man Hours—Total	7,215.00	4,861.00	6,319.00

FOR JOINT USE

ITEM	TOWNSHIPS					
	Menallen		*Tilden*		*New Britain*	
No. of poles required	987		665		1292	
Length of poles	30′	35′	30′	35′	30′	35′

Item	Townships Menallen		Tilden		New Britain	
Unit cost, Class "C" pole	$19.93	$25.66	$19.93	$25.66	$16.46	$22.10
Total cost poles erected	19671	25326	13253	17064	21266	28553
Man Hours per pole .	8.81	10.46	8.81	10.46	5.43	6.36
Total Man Hours	8695	10324	5859	6956	7016	8217

MAPS

On the maps forming Appendix "C" of this analysis are shown the approximate location of farm buildings and the layout of a theoretical pole system to supply telephone service to all farms. It has been assumed that where poles are used jointly by telephone and electric light services, the same pole line routes would be maintained.

In an actual case of new joint construction the ultimate pole routes, pole lengths and types would be determined accurately from a field study of conditions to be met.

In the design shown on the maps, existing telephone central offices have generally been used as reference points for circuit distribution. The change of central office location would, necessarily, affect the design with a resultant change in the total number of poles.

It is further understood that a design for efficient electric light distribution might not be in accordance with the pole layout shown.

SUMMARY

1. Surveys were made of three typical townships.
2. Surveys showed a wider distribution of telephone than electric light service in rural districts.
3. In general, relatively few wires would be required to furnish complete telephone service, very seldom more than six wires in rural districts.
4. This service can be supplied almost entirely on twenty (20) or twenty-five (25) foot grade "E" or "F" poles.
5. Where a territory is being simultaneously developed by telephone and power companies economies will be secured by the joint use of poles under proper conditions.
6. With a telephone line already built and in good condition it may not be economical to rebuild it for joint use, and in general, joint use will require rebuilding unless the line were originally designed for ultimate joint use.
7. When new lines are planned, due consideration should be given to the possibility of joint use.

APPENDIX "A"

The following tables of unit costs for poles were used in the preparation of the pole line cost tables in the analysis. The terms used in tabulating the cost items are defined as follows:

Material Unit—includes the cost of the items of material which are

fixed units in the Company's plant and mileage records. In the case of the exchange pole account, the only unit material included is the pole itself.

Freight—includes the cost of freight at established rates from the point of supply or manufacture to the point of use.

Material—Incidental—includes the cost of all items of material not listed as exempt material which do not of themselves constitute a fixed unit of plant. In the case of exchange poles, this includes such items as pole steps, brackets, hub guards.

Material—Exempt—includes the cost of all materials which are of small value and difficult to keep account of, such as, nails, screws, small bolts and washers, tape, paper sleeves, miscellaneous parts of telephone equipment and porcelain tubing.

Supply Expense—includes all expense (except insurance and taxes) pertaining to the purchase, storage and handling of the distribution of supplies.

Labor—includes salaries and wages of workmen, their foremen and office forces, also the District Superintendents of Plant and their office forces, except District Engineers and Rights of Way Agents. It also includes the cost of board and lodging paid to unlocated line forces in lieu of wages.

Note: It does not include amounts paid for absence due to accidents nor sickness after the first seven days, such payments being chargeable directly to benefit fund accounts.

Plant Supervision Expense—representing the general supervision of the maintenance and construction of the plant, includes salaries, wages and expenses of the General Superintendent of Plant and the Division Superintendents of Plant and their staffs and their respective office forces. It also includes salaries, wages and expenses of instructors in plant schools and the cost of material consumed in school instruction work. This does not include any portion of the amount included in the "Labor" item. Plant Supervision Expense also includes Tool Expense, which represents the cost of exempt tools, that is, tools of small value and short life which it would be difficult to maintain an account of; also the cost of repairs to tools, the value of tools lost or stolen, and depreciation on general tools and implements.

Incidental expense—Includes carfare, vehicle hire and board and lodging directly in connection with a job (except board and lodging which is paid to workmen in lieu of wages), rent paid for temporary storage quarters and other expenditures of miscellaneous nature such as local and minor purchases. It also includes a charge for the use of company owned vehicles which are used in transporting workmen, together with tools and supplies, to and from jobs.

THE BELL TELEPHONE COMPANY OF PENNSYLVANIA, WESTERN DIVISION

Unit Reproduction Costs Jan. 1, 1924.

Class "C" Poles	*25′*	*30′*	*35′*
Material—Unit	$3.98	$4.52	$6.42
Freight	1.24	1.64	1.97

Class "C" Poles	*25'*	*30'*	*35'*
Incidental	.22	.26	.35
Exempt	.02	.03	.04
Supply Expense	.44	.52	.70
Labor	5.71	6.28	7.71
Plant Supervision	.97	1.07	1.31
Incidental Expense	3.12	3.54	4.58
Total	$15.70	$17.86	$23.08
Man Hours	5.61	6.17	7.57

Class "D" Poles	*25'*	*30'*	*35'*
Material—Unit	$3.62	$4.25	$5.97
Freight	1.08	1.36	1.74
Incidental	.20	.24	.33
Exempt	.02	.02	.03
Supply Expense	.39	.47	.65
Labor	5.71	6.28	7.71
Plant Supervision	.97	1.07	1.31
Incidental Expense	2.97	3.39	4.39
Total	$14.96	$17.08	$22.13
Man Hours	5.61	6.17	7.57

Class "E" Poles	*25'*	*30'*	*35'*
Material—Unit	$3.26	$3.98	$5.70
Freight	.84	1.13	1.52
Incidental	.17	.21	.31
Exempt	.02	.02	.03
Supply Supervision	.34	.43	.60
Labor	5.71	6.28	7.71
Plant Supervision	.97	1.07	1.31
Incidental Expense	2.81	3.25	4.26
Total	$14.12	$16.37	$21.44
Man Hours	5.61	6.17	7.57

NOTE: These costs are based on actual experience covering pole work in that portion of Pennsylvania west of the Allegheny Mountains. Nothing is included in these costs for the following seven items:

1. Engineering.
2. General Administration.
3. Insurance (Workmen's and Public Liability during Construction).
4. Interest during construction.

(Proper allowance for the four items named above will increase the cost of the work 11.632%.)

5. Cost of obtaining rights of way.
6. Cost of Securing Money.
7. Any Development or Other Going Concern Costs.

THE BELL TELEPHONE COMPANY OF PENNSYLVANIA, EASTERN DIVISION

Unit Reproduction Cost Jan. 1, 1924.

Class "C" Poles	*25′*	*30′*	*35′*
Material—Unit	$3.80	$4.34	$7.05
Freight	1.44	1.90	2.30
Incidental	.32	.39	.58
Exempt	.04	.05	.07
Supply Expense	.45	.53	.80
Labor	5.03	5.59	6.54
Plant Supervision	.77	.86	1.00
Incidental Expense	2.43	2.80	3.76
Total	$14.28	$16.46	$22.10
Man Hours	4.89	5.43	6.36
Class "D" Poles	*25′*	*30′*	*35′*
Material—Unit	$3.26	$4.07	$6.78
Freight	1.26	1.58	2.03
Incidental	.28	.35	.55
Exempt	.03	.04	.06
Supply Expense	.39	.48	.75
Labor	5.03	5.59	6.54
Plant Supervision	.77	.86	1.00
Incidental Expense	2.26	2.66	3.63
Total	$13.28	$15.63	$21.34
Man Hours	$4.89	$5.43	$6.36
Class "E" Poles	*25′*	*30′*	*35′*
Material—Unit	$2.71	$3.80	$6.51
Freight	.98	1.31	1.76
Incidental	.23	.32	.51
Exempt	.03	.04	.06
Supply Expense	.32	.44	.71
Labor	5.03	5.59	6.54
Plant Supervision	.77	.86	1.00
Incidental Expense	2.06	2.53	3.50
Total	$12.13	$14.89	$20.59
Man Hours	4.89	5.43	6.36

NOTE: These costs are based on actual experience covering pole work in Bucks, Chester, Delaware and Montgomery Counties, Pennsylvania.

Nothing is included in these costs for the following seven items:

1. Engineering.
2. General Administration.
3. Insurance (Workmen's and Public Liability during Construction).
4. Interest during construction.

(Proper allowance for the four items named above will increase the cost of the work 11.632%.)

5. Cost of obtaining Rights of Way.
6. Cost of Securing Money.
7. Any Development or Other Going Concern Costs.

THE BELL TELEPHONE COMPANY OF PENNSYLVANIA, HARRISBURG DIVISION

Unit Reproduction Cost Jan. 1, 1924.

Class "C" Poles	*25'*	*30'*	*35'*
Material—Unit	$3.80	$4.34	$6.08
Freight	.99	1.31	1.58
Incidental	.23	.27	.37
Exempt	.06	.07	.10
Supply Expense	.41	.48	.65
Labor	7.81	8.98	11.17
Plant Supervision	1.35	1.55	1.93
Incidental Expense	2.53	2.93	3.78
Total	$17.18	$19.93	$25.66
Man Hours	7.31	8.41	10.46
Class "D" Poles	*25'*	*30'*	*35'*
Material—Unit	$3.26	$4.07	$5.81
Freight	.87	1.09	1.40
Incidental	.20	.25	.35
Exempt	.05	.07	.09
Supply Expense	.35	.44	.61
Labor	7.81	8.98	11.17
Plant Supervision	1.35	1.55	1.93
Incidental Expense	2.39	2.84	3.69
Total	$16.28	$19.29	$25.05
Man Hours	7.31	8.41	10.46
Class "E" Poles	*25'*	*30'*	*35'*
Material—Unit	$2.71	$3.80	$5.54
Freight	.68	.90	1.21
Incidental	.16	.23	.33
Exempt	.04	.06	.09
Supply Expense	.29	.40	.57
Labor	7.81	8.98	11.17
Plant Supervision	1.35	1.55	1.93
Incidental Expense	2.25	2.75	3.60
Total	$15.29	$18.67	$24.44
Man Hours	7.31	8.41	10.46

Note: These costs are based on actual experience covering pole work in that portion of Pennsylvania east of the Allegheny Mountains, but not including Bucks, Chester, Delaware, Montgomery and Philadelphia Counties.

Nothing is included in these costs for the following seven items—

1. Engineering.

2. General Administration.
3. Insurance (Workmen's and Public Liability during Construction).
4. Interest during construction.

(Proper allowance for the four items named above will increase the cost of the work 11.632%).

5. Cost of obtaining Rights of Way.
6. Cost of Securing Money.
7. Any Developmental or Other Going Concern Costs.

APPENDIX B

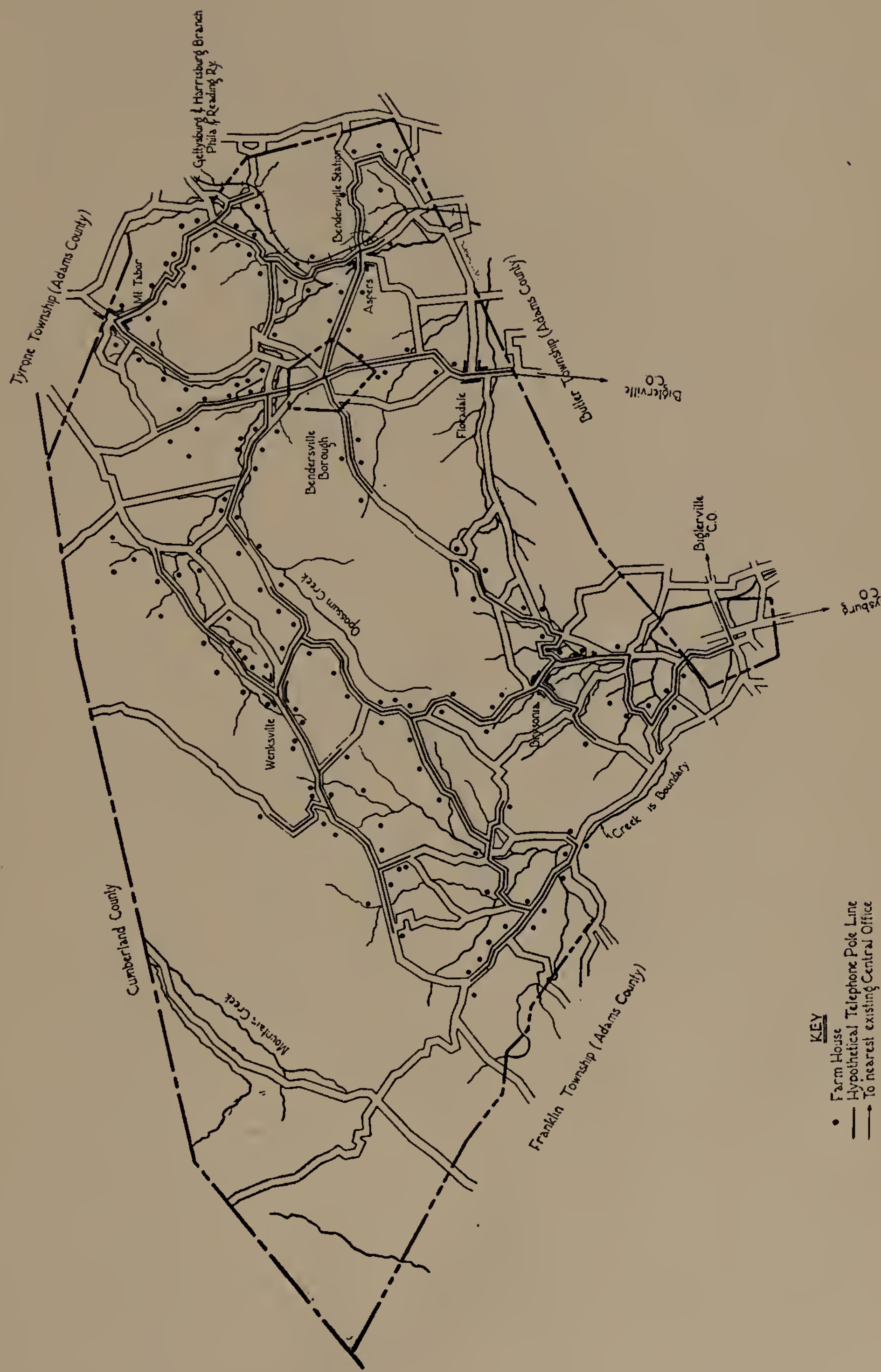
Bell System Specifications for Class C, D, E and F Chestnut Poles.

Dimensions are circumference measurements 6′ from butt end.

Length of Pole	*Class* "C"	"D"	"E"	"F"
25′	32″	29″	27″	No. Min.
30′	34″	32″	29″	Butt Requirement
35′	36″	34″	32″	
Cir. at top	20″	18″	16″	15″

APPENDIX C

TILDEN TOWNSHIP, BERKS COUNTY



MENALLEN TOWNSHIP, ADAMS COUNTY

NEW BRITAIN TOWNSHIP, BUCKS COUNTY